US008787198B2

(12) **United States Patent**
**Osborn**

(10) **Patent No.: US 8,787,198 B2**
(45) **Date of Patent: *Jul. 22, 2014**

(54) **SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR AUTHENTICATION CENTER-INITIATED AUTHENTICATION PROCEDURES FOR A MOBILE STATION ATTACHED WITH AN IP-FEMTOCELL SYSTEM**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/970,326**

(22) Filed: **Aug. 19, 2013**

(65) **Prior Publication Data**

US 2013/0331059 A1 Dec. 12, 2013

**Related U.S. Application Data**

(63) Continuation of application No. 12/605,519, filed on Oct. 26, 2009, now Pat. No. 8,547,859, which is a continuation-in-part of application No. 12/252,231, filed on Oct. 15, 2008, now Pat. No. 8,194,590, which is a continuation-in-part of application No. 12/252,246, filed on Oct. 15, 2008, now Pat. No. 8,351,901, which is a continuation-in-part of application No. 12/252,238, filed on Oct. 15, 2008.

(60) Provisional application No. 61/003,151, filed on Nov. 15, 2007.

(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 4/00*** | (2009.01) |
| *H04M 1/66* | (2006.01) |
| *H04M 1/68* | (2006.01) |

(52) **U.S. Cl.**
USPC ..... **370/252**; 370/328; 455/411; 455/435.1

(58) **Field of Classification Search**
CPC ..... H04W 12/06; H04W 60/00; H04W 84/12
USPC ..... 370/252, 328, 411, 435.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 7,174,177 | B1 * | 2/2007 | Chander et al. | 455/466 |
| 8,249,554 | B2 * | 8/2012 | Mack et al. | 455/411 |
| 2006/0154646 | A1 * | 7/2006 | Tung | 455/411 |
| 2008/0318551 | A1 * | 12/2008 | Palamara et al. | 455/411 |
| 2009/0172397 | A1 * | 7/2009 | Kim | 713/168 |
| 2009/0191844 | A1 * | 7/2009 | Morgan et al. | 455/411 |
| 2010/0048176 | A1 * | 2/2010 | Osborn | 455/411 |
| 2012/0184249 | A1 * | 7/2012 | Morgan et al. | 455/411 |
| 2012/0238247 | A1 * | 9/2012 | Wen et al. | 455/411 |

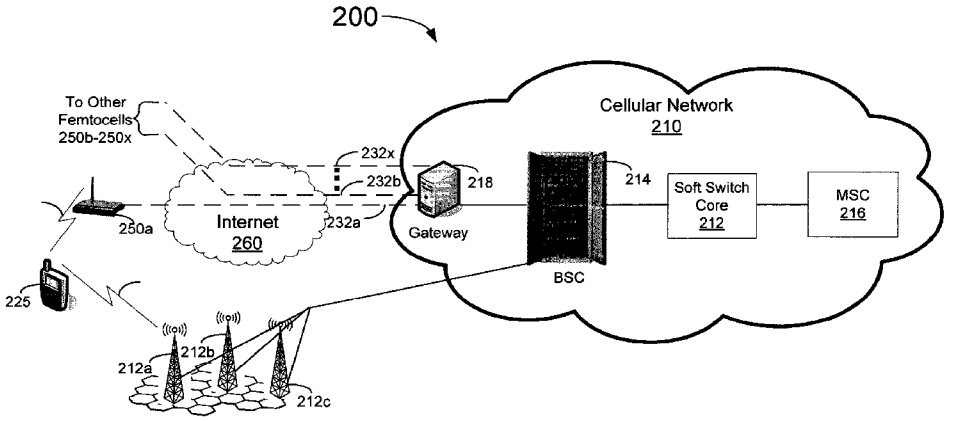
* cited by examiner

*Primary Examiner* — Farah Faroul

(57) **ABSTRACT**

A system, method, and computer readable medium that facilitate authentication center-initiated authentication procedures for a mobile station attached with a femtocell system are provided. A femtocell system may generate a registration identification of a mobile station from one or more mobile station authentication parameters. A convergence server located in a core network receives an authentication procedure request from an authentication center for the mobile station attached with the femtocell system and generates an authentication procedure request message that includes the registration identification assigned to the mobile station. The convergence server then transmits the authentication procedure request message to the femtocell system and receives a response to the authentication procedure request message from the femtocell system. The authentication procedure request may comprise a unique challenge, a shared secret data update procedure, or a call history count update procedure.

**16 Claims, 13 Drawing Sheets**



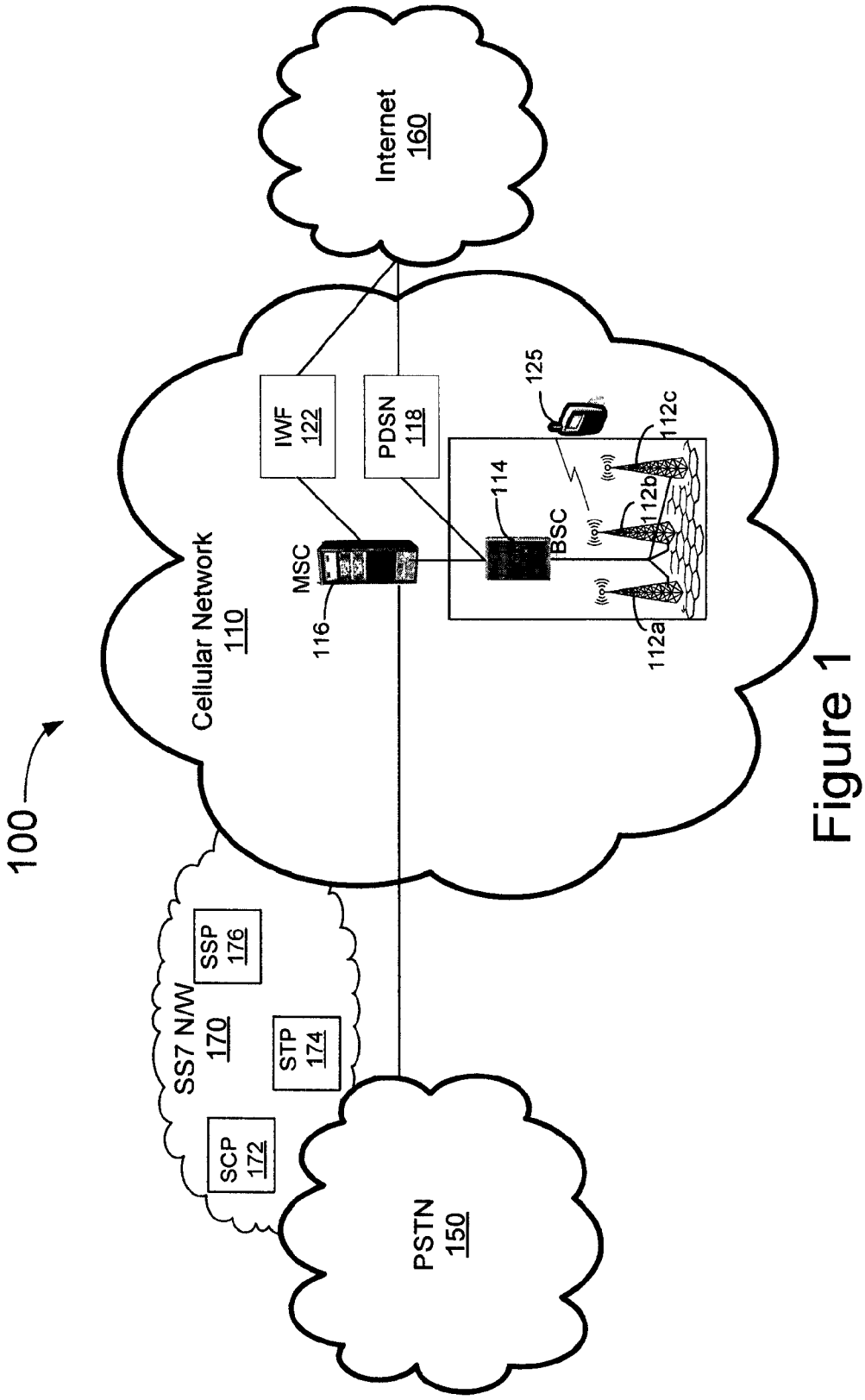

100
Internet
160
Cellular Network
110
IWF
122
PDSN
118
MSC
116
BSC
114
125
112a
112b
112c
SS7 N/W
170
SSP
176
STP
174
SCP
172
PSTN
150

Figure 1

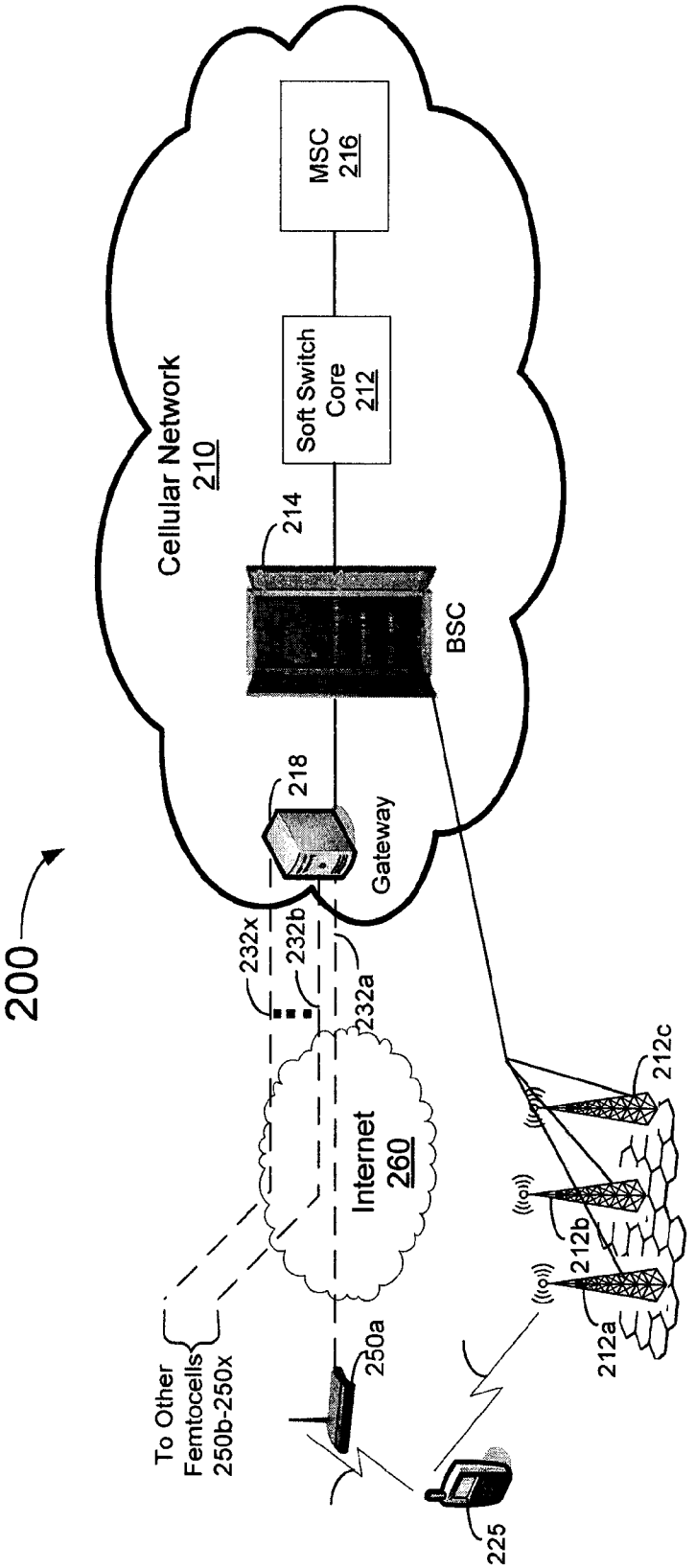

200
Cellular Network
210
MSC
216
Soft Switch
Core
212
214
BSC
218
Gateway
232x
232b
232a
Internet
260
To Other
Femtocells
250b-250x
250a
225
212a
212b
212c

Figure 2

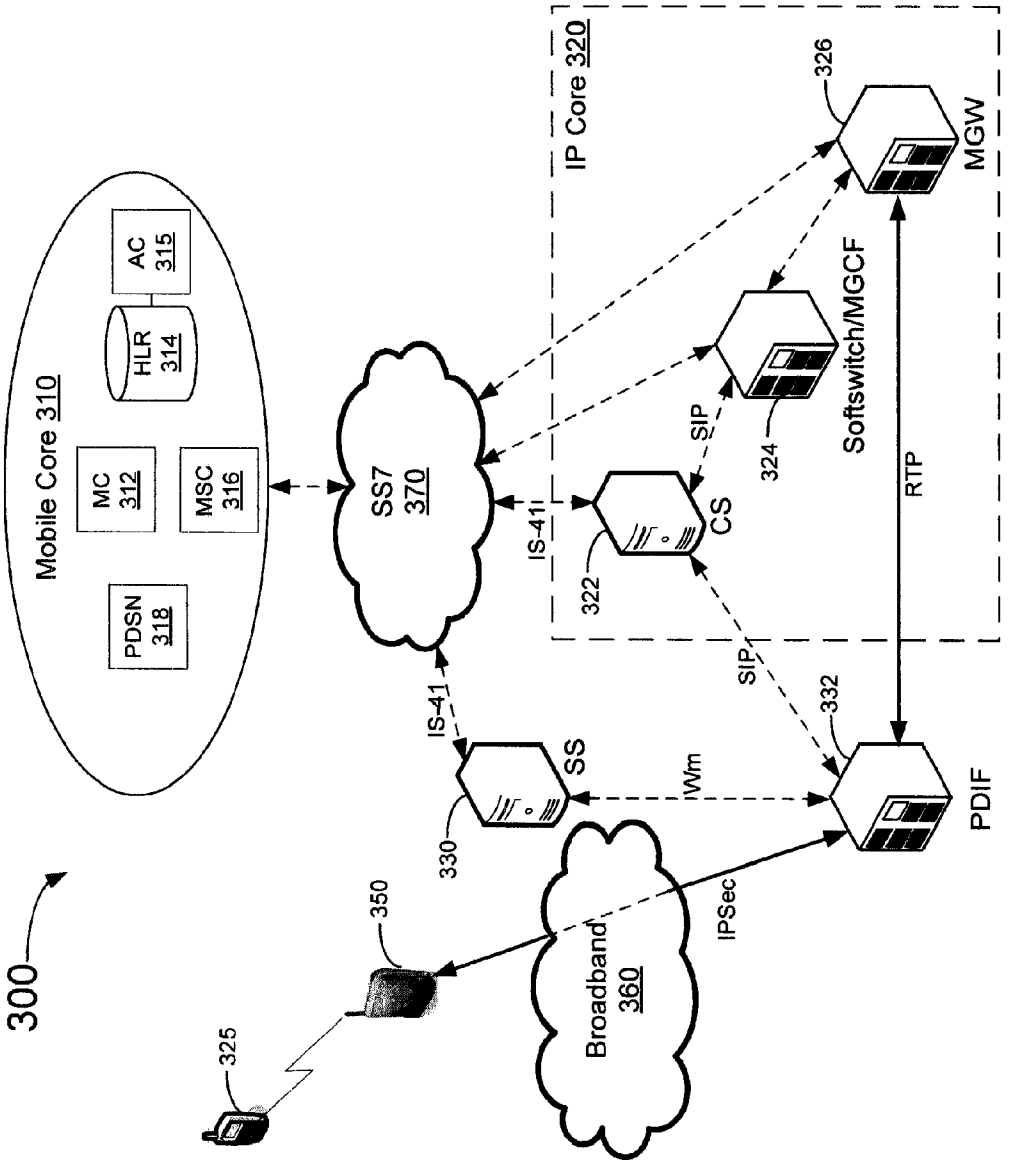

300
Mobile Core 310
AC 315
HLR 314
MC 312
MSC 316
PDSN 318
SS7 370
IP Core 320
MGW
326
Softswitch/MGCF
SIP
324
IS-41
CS
322
RTP
SIP
IS-41
SS
330
Wm
332
PDIF
350
Broadband 360
IPSec
325

Figure 3A

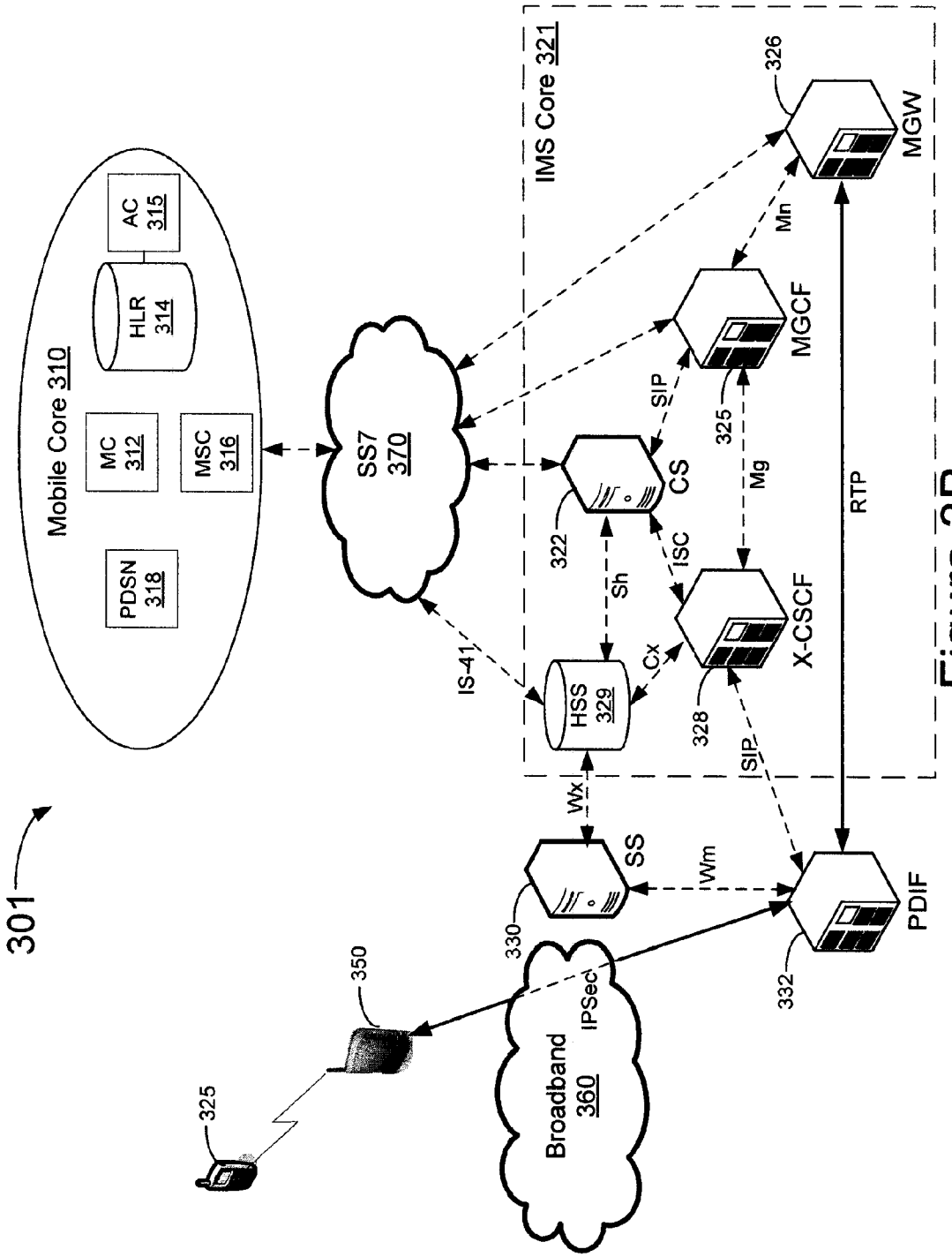

301
Mobile Core 310
AC 315
HLR 314
MC 312
MSC 316
PDSN 318
SS7 370
IS-41
IMS Core 321
MGW 326
MGCF
CS 322
X-CSCF
HSS 329
SS 330
PDIF 332
Broadband 360
IPSec
350
325
Mn
SIP
Mg
RTP
ISC
Sh
Cx
Wx
Wm
328

Figure 3B

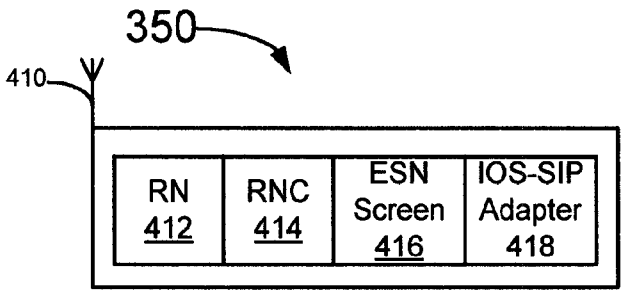



Figure 4

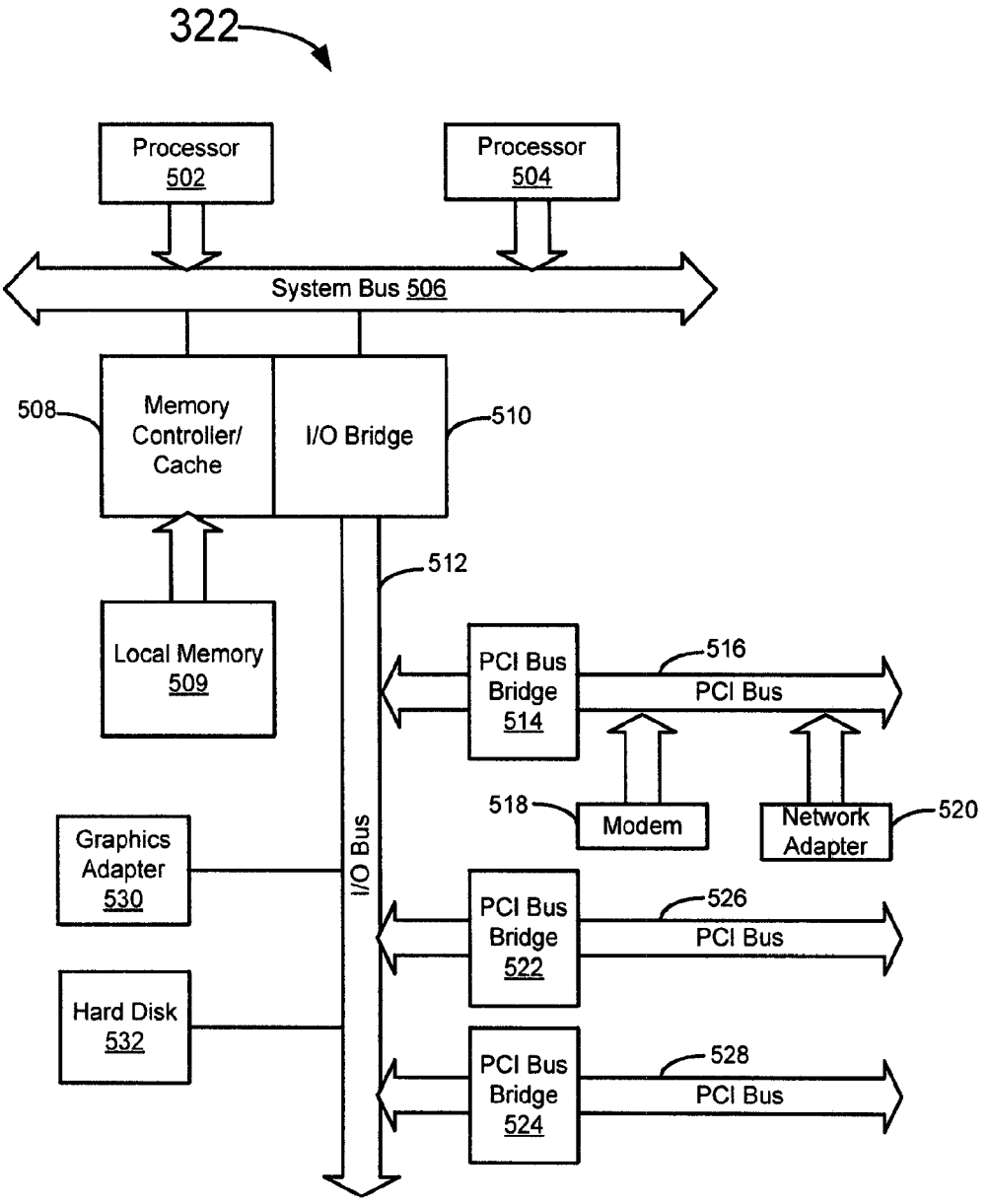



Figure 5

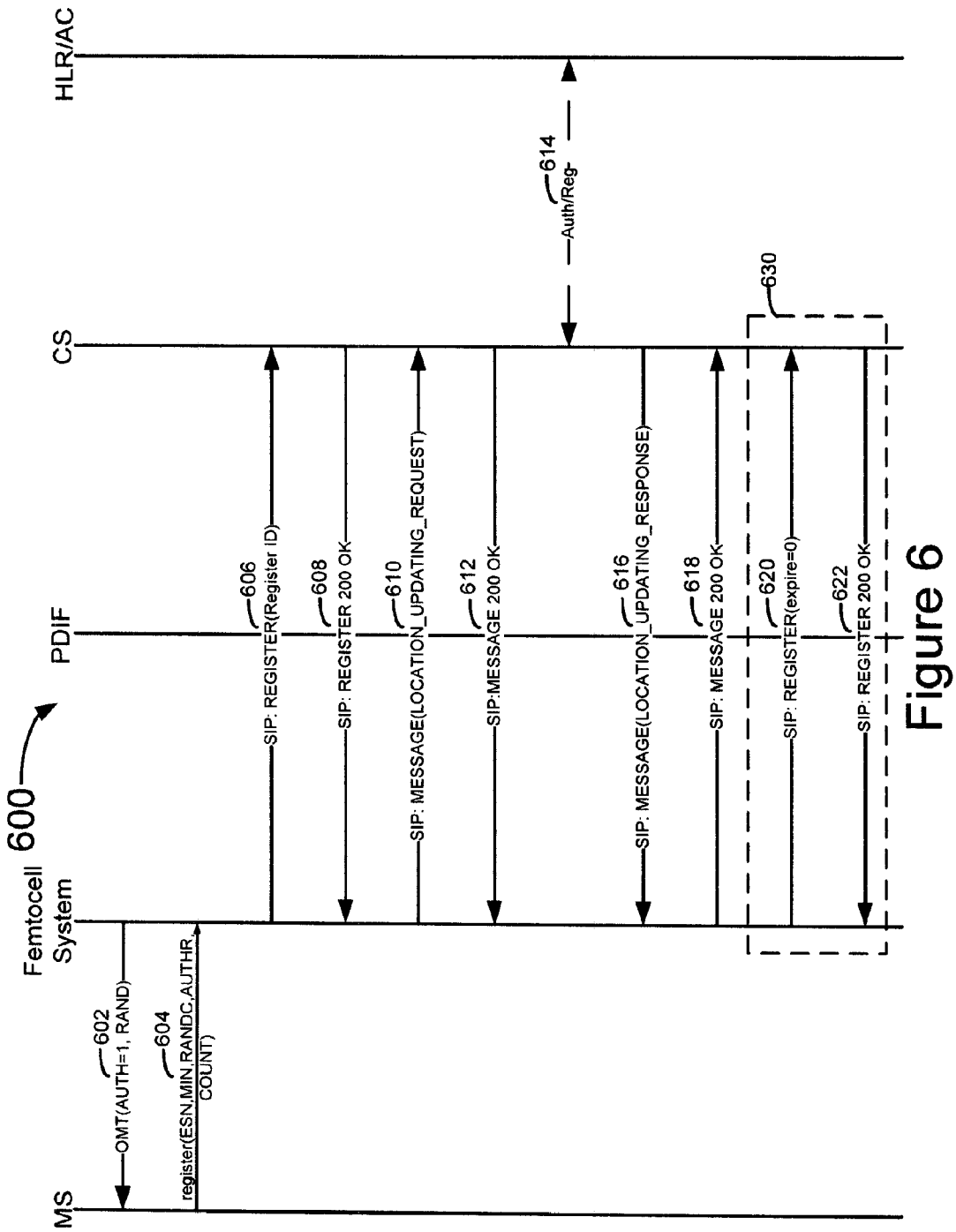

600
Femtocell System
MS
PDIF
CS
HLR/AC
602
OMT(AUTH=1, RAND)
604
register(ESN,MIN,RANDC,AUTHR, COUNT)
606
SIP: REGISTER(Register ID)
608
SIP: REGISTER 200 OK
610
SIP: MESSAGE(LOCATION_UPDATING_REQUEST)
612
SIP:MESSAGE 200 OK
614
Auth/Reg
616
SIP: MESSAGE(LOCATION_UPDATING_RESPONSE)
618
SIP: MESSAGE 200 OK
620
SIP: REGISTER(expire=0)
622
SIP: REGISTER 200 OK
630

Figure 6

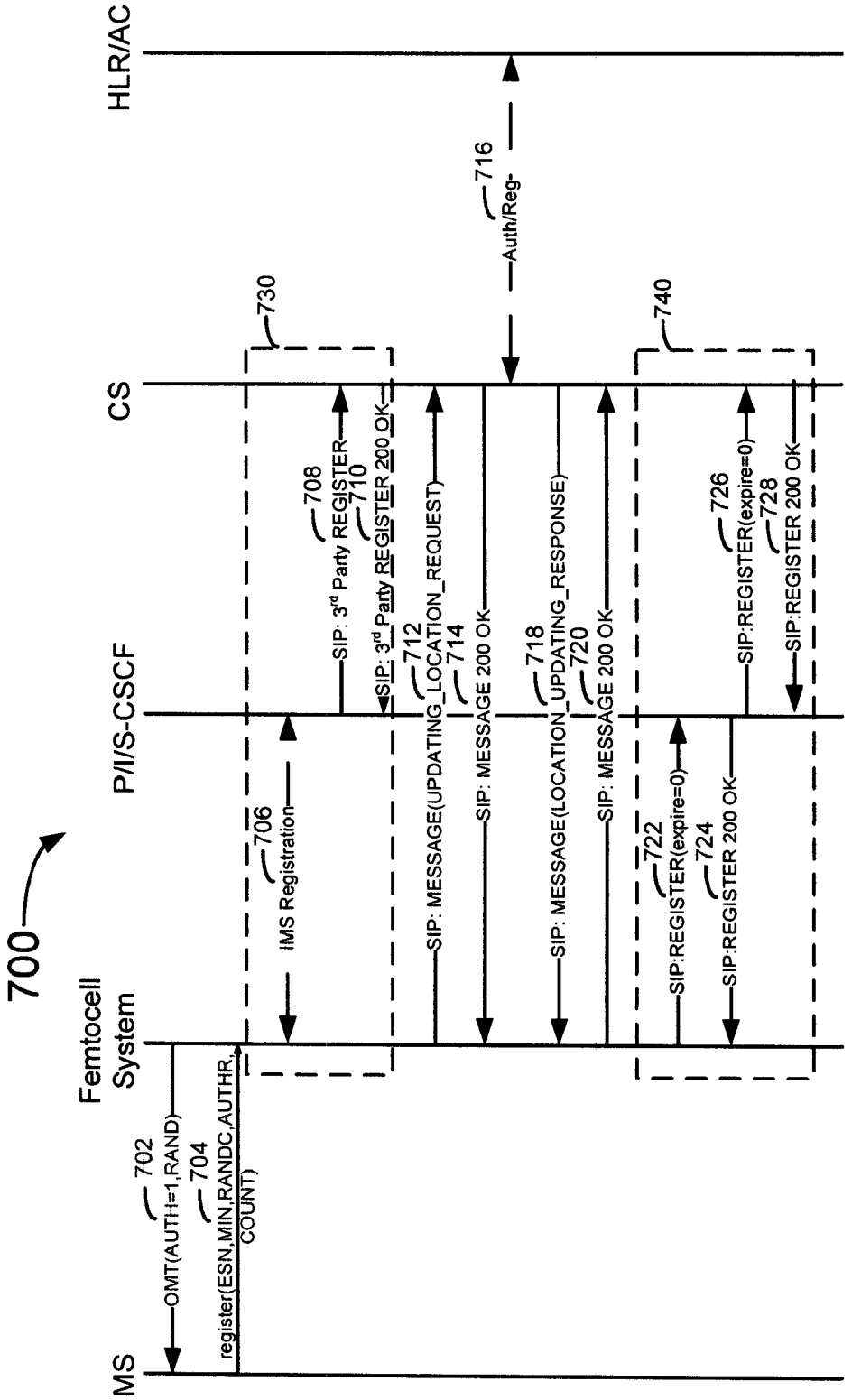

700
MS
Femtocell System
P/I/S-CSCF
CS
HLR/AC
702
OMT(AUTH=1,RAND)
704
register(ESN,MIN,RANDC,AUTHR, COUNT)
706
IMS Registration
708
SIP: 3rd Party REGISTER
710
SIP: 3rd Party REGISTER 200 OK
712
SIP: MESSAGE(UPDATING_LOCATION_REQUEST)
714
SIP: MESSAGE 200 OK
716
Auth/Reg-
718
SIP: MESSAGE(LOCATION_UPDATING_RESPONSE)
720
SIP: MESSAGE 200 OK
722
SIP:REGISTER(expire=0)
724
SIP:REGISTER 200 OK
726
SIP:REGISTER(expire=0)
728
SIP:REGISTER 200 OK
730
740

Figure 7

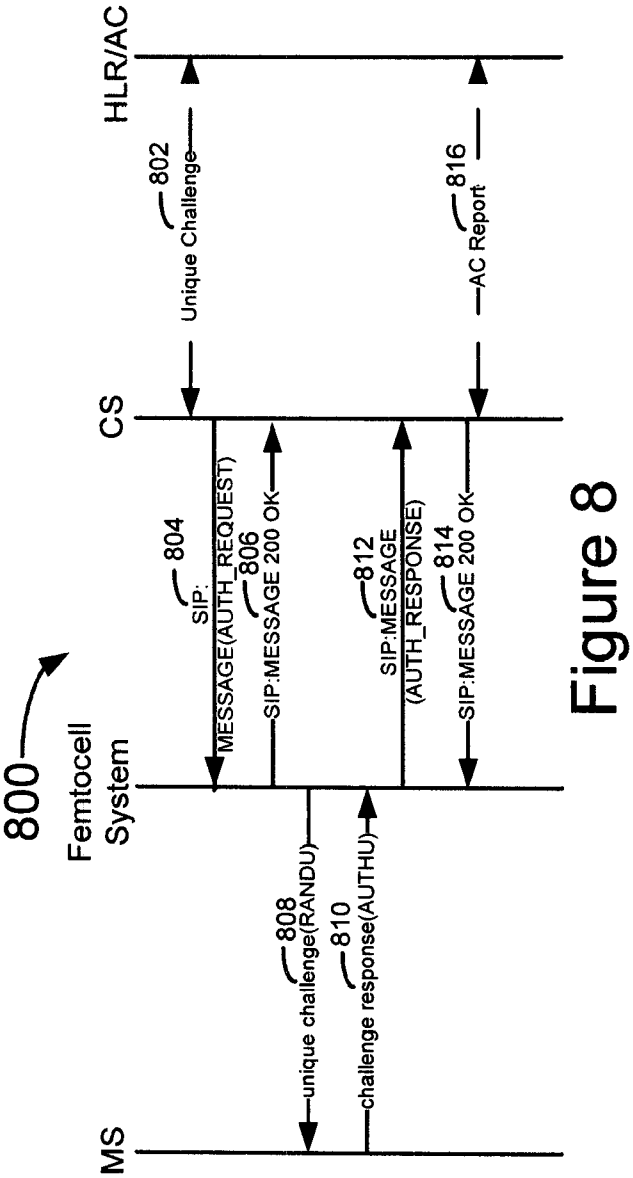

HLR/AC
CS
MS
800
Femtocell System
802
Unique Challenge
804
SIP: MESSAGE(AUTH_REQUEST)
806
SIP:MESSAGE 200 OK
808
unique challenge(RANDU)
810
challenge response(AUTHU)
812
SIP:MESSAGE (AUTH_RESPONSE)
814
SIP:MESSAGE 200 OK
816
AC Report

Figure 8

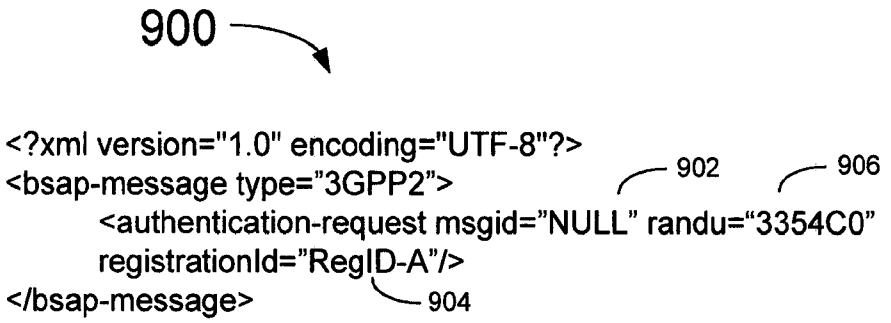



Figure 9A

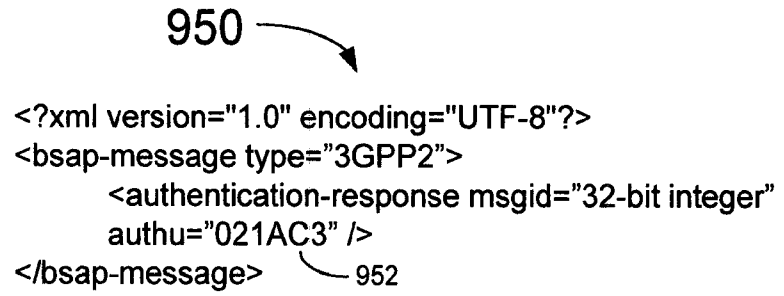



Figure 9B

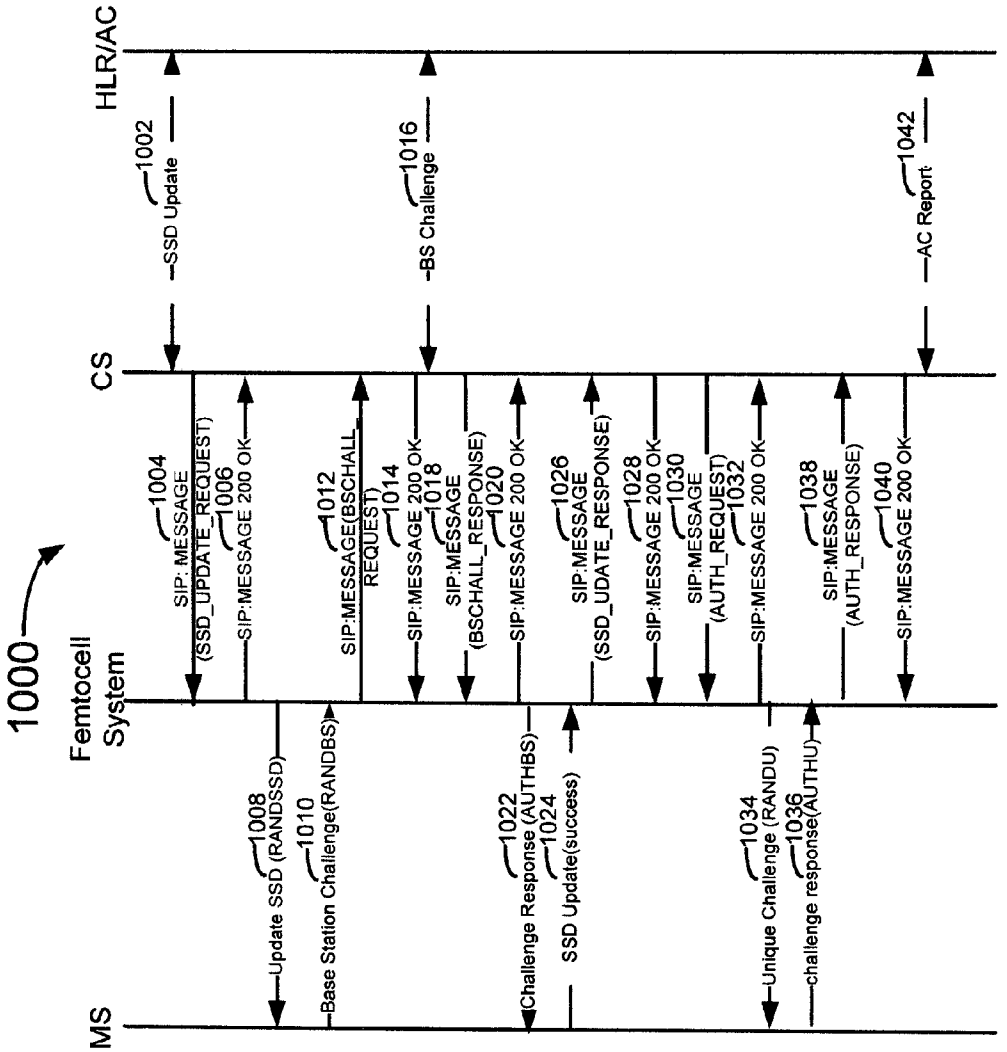

1000
Femtocell System
HLR/AC
CS
MS
1002 SSD Update
1004 SIP: MESSAGE (SSD_UPDATE_REQUEST)
1006 SIP:MESSAGE 200 OK
1008 Update SSD (RANDSSD)
1010 Base Station Challenge(RANDBS)
1012 SIP:MESSAGE(BSCHALL REQUEST)
1014 SIP:MESSAGE 200 OK
1016 BS Challenge
1018 SIP:MESSAGE (BSCHALL_RESPONSE)
1020 SIP:MESSAGE 200 OK
1022 Challenge Response (AUTHBS)
1024 SSD Update(success)
1026 SIP:MESSAGE (SSD_UDATE_RESPONSE)
1028 SIP:MESSAGE 200 OK
1030 SIP:MESSAGE (AUTH_REQUEST)
1032 SIP:MESSAGE 200 OK
1034 Unique Challenge (RANDU)
1036 challenge response(AUTHU)
1038 SIP:MESSAGE (AUTH_RESPONSE)
1040 SIP:MESSAGE 200 OK
1042 AC Report

Figure 10

1100

```
<?xml version="1.0" encoding="UTF-8"?>
<bsap-message type="3GPP2">                    1102
        <ssd-update-request msgid="NULL"
        randssd="D3568710A76E21"
registrationId="RegID-A"/>          1106
</bsap-message>          1104
```

Figure 11A

1120

```
<?xml version="1.0" encoding="UTF-8"?>
<bsap-message type="3GPP2">
        <ssd-update-response msgid="32-bit integer" layer3-cause-code="0F/
3B" layer3-causetext=" failed/rejected"/>
</bsap-message>
```

Figure 11B

1140

```
                                        1142
<?xml version="1.0" encoding="UTF-8"?>
<bsap-message type="3GPP2">          1142
        <bschall-request msgid="NULL" randbs="21AC30A5" />
</bsap-message>
```

Figure 11C

1160

```
<?xml version="1.0" encoding="UTF-8"?>
<bsap-message type="3GPP2">                                    1162
        <bschall-response msgid="32-bit integer" authbs="021AC3" />
</bsap-message>
```

Figure 11D

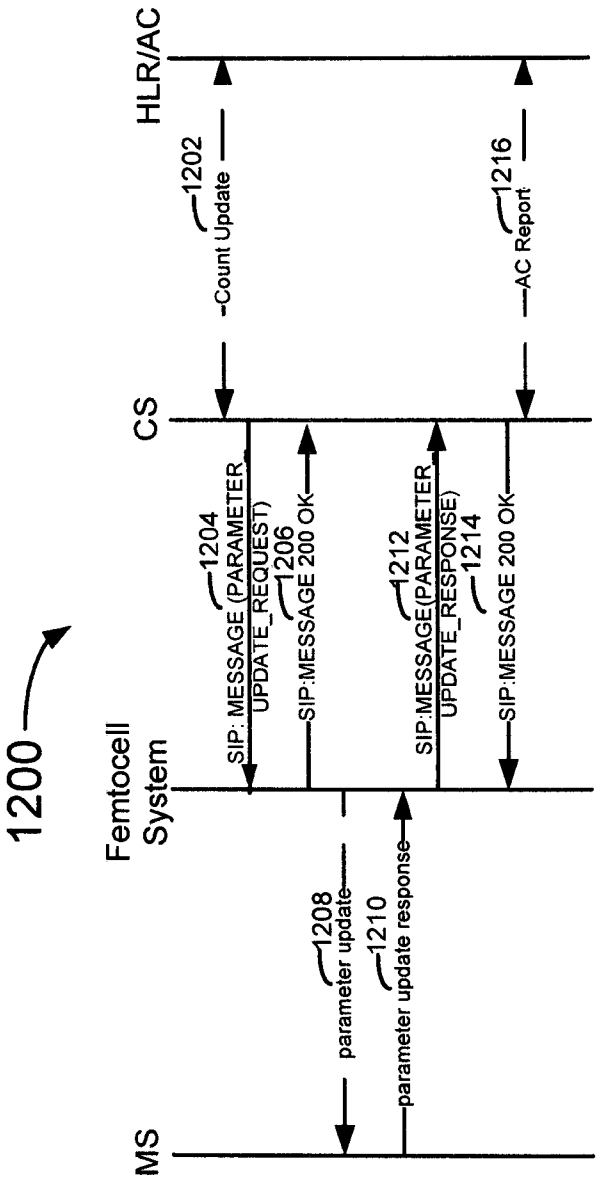
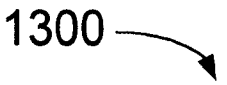
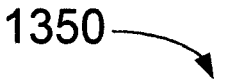

1200
Femtocell System
HLR/AC
CS
MS
1202
Count Update
1204
SIP: MESSAGE (PARAMETER UPDATE_REQUEST)
1206
SIP:MESSAGE 200 OK
1208
parameter update
1210
parameter update response
1212
SIP:MESSAGE(PARAMETER UPDATE_RESPONSE)
1214
SIP:MESSAGE 200 OK
1216
AC Report

Figure 12




```
<?xml version="1.0" encoding="UTF-8"?>
<bsap-message type="3GPP2">                    1302
        <parameter-update-request msgid=NULL
        registrationId="RegID-A"/>
</bsap-message>                  1304
```

Figure 13A




```
<?xml version="1.0" encoding="UTF-8"?>
<bsap-message type="3GPP2">
        <parameter-update-response msgid="32-bit integer" successful-
        update="true/false" />
</bsap-message>      1352
```

Figure 13B

# SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR AUTHENTICATION CENTER-INITIATED AUTHENTICATION PROCEDURES FOR A MOBILE STATION ATTACHED WITH AN IP-FEMTOCELL SYSTEM

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. Ser. No. 12/605,519 filed Oct. 26, 2009, entitled "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR AUTHENTICATION CENTER-INITIATED AUTHENTICATION PROCEDURES FOR A MOBILE STATION ATTACHED WITH AN IP-FEMTOCELL SYSTEM", which is a continuation-in-part of U.S. Ser. No. 12/252,231 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR PROCESSING CALL ORIGINATIONS BY A FEMTOCELL SYSTEM", now issued U.S. Pat. No. 8,194,590 issued on Jun. 5, 2012, which is a continuation-in-part of U.S. Ser. No. 12/252,246, filed on Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR USER EQUIPMENT REGISTRATION AND AUTHENTICATION PROCESSING BY A FEMTOCELL SYSTEM", now issued U.S. Pat. No. 8,351,901, issued on Jan. 8, 2013, which is a continuation-in-part of U.S. Ser. No. 12/252,238 filed on Oct. 15, 2008, entitled "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR SHORT MESSAGE SERVICE PROCESSING BY A FEMTOCELL SYSTEM", each of which claims priority to U.S. provisional patent application Ser. No. 61/003,151 filed Nov. 15, 2007, entitled, "SIP-IOS adapter function", the disclosures of each of which are incorporated herein by reference. Incorporated by reference is U.S. Ser. No. 12/252,237 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR CALL TERMINATION PROCESSING BY A FEMTOCELL SYSTEM" and U.S. Ser. No. 12/252,242 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR SHORT MESSAGE SERVICE TERMINATION PROCESSING BY A FEMTOCELL SYSTEM", now issued U.S. Pat. No. 8,351,963 issued on Jan. 8, 2013, and U.S. Ser. No. 12/252,199 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR IP-FEMTOCELL PROVISIONED RADIO ACCESS NETWORK", now issued U.S. Pat. No. 8,103,274 issued on Jan. 24, 2012, and U.S. Ser. No. 12/252,202 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR USER EQUIPMENT HANDOFF WITHIN AN IP-FEMTOCELL NETWORK" and U.S. Ser. No. 12/252,204 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR USER EQUIPMENT ACQUISITION OF AN IP-FEMTOCELL SYSTEM" and U.S. Ser. No. 12/252,210 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR USER EQUIPMENT HANDOFF FROM A MACROCELLULAR NETWORK TO AN IP-FEMTOCELL NETWORK" and U.S. Ser. No. 12/252,212 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR CONFIGURATION OF AN IP-FEMTOCELL SYSTEM" and U.S. Ser. No. 12/252,217 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR MOBILE-TO-MOBILE CALLS WITHIN FEMTOCELL NETWORK", now issued U.S. Pat. No. 8,224,291 issued on Jul. 17, 2012, and U.S. Ser. No. 12/252,222 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR ACCESS RESTRICTION OF USER EQUIPMENT DEVICES IN AN IP-FEMTOCELL SYSTEM" and U.S. Ser. No. 12/252,226 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR ABBREVIATED-CODE DIALING IN A NETWORK SYSTEM", now issued U.S. Pat. No. 8,346,216 issued on Jan. 1, 2013, and U.S. Ser. No. 12/252,227 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR MULTI-STAGE TRANSMIT PROTECTION IN A FEMTOCELL SYSTEM" and U.S. Ser. No. 12/252,234 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR MOBILE TERMINATED CALL PROCESSING BY A FEMTOCELL SYSTEM", now issued U.S. Pat. No. 8,059,585 filed on Nov. 15, 2011, and PCT Ser. No. PCT/US08/80031 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR PROCESSING CALL ORIGINATIONS BY A FEMTOCELL SYSTEM" and PCT Ser. No. PCT/US08/80032 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR SHORT MESSAGE SERVICE PROCESSING BY A FEMTOCELL SYSTEM" and PCT Ser. No. PCT/US08/80033 filed Oct. 15, 2008, entitled, "SYSTEM, METHOD, AND COMPUTER-READABLE MEDIUM FOR USER EQUIPMENT REGISTRATION AND AUTHENTICATION PROCESSING BY A FEMTOCELL SYSTEM".



## FIELD OF THE INVENTION

The present invention is generally related to radio access technologies and, more particularly, to mechanisms for facilitating mobile station registration and authentication via a femtocell system.

## BACKGROUND OF THE INVENTION

Contemporary cellular radio systems, or mobile telecommunication systems, provide an over-the-air interface to wireless mobile stations (MSs), also referred to as user equipments (UEs), via a radio access network (RAN) that interfaces with at least one core network. The RAN may be implemented as, for example, a CDMA2000 RAN, a Universal Mobile Telecommunications System (UMTS) RAN, a Global System for Mobile communications (GSM) RAN, or another suitable radio access network implementation. The MSs may comprise, for example, a mobile terminal such as a mobile telephone, a laptop computer featuring mobile telephony software and hardware, a personal digital assistant (PDA), or other suitable equipment adapted to transfer and receive voice or data communications with the radio access network.

A RAN covers a geographical area comprised of any number of cells each comprising a relatively small geographic area of radio coverage. Each cell is provisioned by a cell site that includes a radio tower, e.g., a base transceiver station (BTS), and associated equipment. BTSs communicate with MSs over an air interface within radio range of the BTSs.

Numerous BTSs in the RAN may be communicatively coupled to a base station controller (BSC), also commonly referred to as a radio network controller (RNC). The BSC manages and monitors various system activities of the BTSs serviced thereby. BSCs are typically coupled with at least one core network.

BTSs are typically deployed by a carrier network in areas having a high population density. The traffic capacity of a cell site is limited by the site's capacity and affects the spacing of cell sites. In suburban areas, sites are often up to two miles apart, while cell sites deployed in dense urban areas may be as close as one-quarter of a mile apart. Because the traffic capacity of a cell site is finitely limited, as is the available frequency spectrum, mobile operators have a vested interest in technologies that allow for increased subscriber capacity.

A microcell site comprises a cell in a mobile phone network that covers a limited geographic area, such as a shopping center, hotel, airport, or other infrastructure that may have a high density mobile phone usage. A microcell typically uses power control to limit the radius of the microcell coverage. Typically a microcell is less than a mile wide.

Although microcells are effective for adding network capacity in areas with high mobile telephone usage, microcells extensively rely on the RAN, e.g., a controlling BSC and other carrier functions. Because contemporary BSCs have limited processing and interface capacity, the number of BTSs—whether microcell BTSs or typical carrier BTSs—able to be supported by the BSC or other RAN functions is disadvantageously limited.

Contemporary interest exists in providing enterprise and office access, including small office/home office (SOHO) radio access, by an even smaller scale BTS. The radio coverage area of such a system is typically referred to as a femtocell. In a system featuring a femtocell, an MS may be authorized to operate in the femtocell when proximate the femtocell system, e.g., while the MS is located in the SOHO. When the MS moves beyond the coverage area of the femtocell, the MS may then be serviced by the carrier network. The advantages of deployment of femtocells are numerous. For instance, mobile users frequently spend large amounts of time located at, for example, home, and many such users rely extensively on cellular network service for telecommunication services during these times. For example, a recent survey indicated that nearly thirteen percent of U.S. cell phone customers do not have a landline telephone and rely solely on cell phones for receiving telephone service. From a carrier perspective, it would be advantageous to have telephone services provisioned over a femtocell system, e.g., deployed in the user's home, to thereby reduce the load and effectively increase the capacity on the carrier RAN infrastructure. However, no efficient mechanisms have been provided for efficiently providing a convergence of femtocell and macrocellular systems in a manner that facilitates registration and authentication of mobile stations via a femtocell system.

Therefore, what is needed is a mechanism that overcomes the described problems and limitations.

## SUMMARY OF THE INVENTION

The present invention provides a system, method, and computer readable medium for facilitating authentication center-initiated authentication procedures for a mobile station attached with a femtocell system. A femtocell system may generate a registration identification of a mobile station from one or more mobile station authentication parameters. A convergence server located in a core network receives an authentication procedure request from an authentication center for the mobile station attached with the femtocell system and generates an authentication procedure request message that includes a registration identifier assigned to the mobile station. The convergence server then transmits the authentication procedure request message to the femtocell system and receives a response to the authentication procedure request message from the femtocell system. In an embodiment, the authentication procedure request comprises a unique challenge. In another embodiment, the authentication procedure request comprises a shared secret data update procedure. In yet another embodiment, the authentication procedure request comprises a call history count update procedure.

In accordance with an embodiment, a method of providing an authentication center-initiated authentication procedure to a mobile station attached with a femtocell system is provided. The method includes receiving, by a convergence server located in a core network, an authentication procedure request from an authentication center for the mobile station attached with the femtocell system, generating, by the convergence server, an authentication procedure request message that includes a registration identifier assigned to the mobile station, transmitting, by the convergence server, the authentication procedure request message to the femtocell system, and receiving, by the convergence server, a response to the authentication procedure request message from the femtocell system.

In accordance with another embodiment, a computer-readable medium having computer-executable instructions tangibly embodied thereon for execution by a processing system, the computer-executable instructions for providing an authentication center-initiated authentication procedure to a mobile station attached with a femtocell system, is provided. The computer-readable medium includes instructions that, when executed, cause the processing system to receive, by a convergence server located in a core network, an authentication procedure request from an authentication center for the mobile station attached with the femtocell system, generate, by the convergence server, an authentication procedure request message that includes a registration identifier assigned to the mobile station, transmit, by the convergence server, the authentication procedure request message to the femtocell system, receive, by the convergence server, a response to the authentication procedure request message from the femtocell system, and map the authentication procedure to the mobile station using the registration identifier.

In accordance with another embodiment, a network system that provides authentication center-initiated authentication procedures for mobile stations is provided. The network system includes a core network that includes a convergence server, a mobile core network that includes an authentication center, and an Internet Protocol-based femtocell system that provides a radio access point for a mobile station. The convergence server receives an authentication procedure request from the authentication center for the mobile station, generates an authentication procedure request message that includes a registration identifier assigned to the mobile station, transmits the authentication procedure request message to the femtocell system, and receives a response to the authentication procedure request message from the femtocell system. The femtocell system maps the authentication procedure to the mobile station using the registration identifier.

## BRIEF DESCRIPTION OF THE DRAWINGS

Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures, in which:

FIG. **1** is a diagrammatic representation of a network system that includes a cellular network adapted to provide macro-cellular coverage to a mobile station;

FIG. **2** is a diagrammatic representation of a conventional network system configuration featuring a femtocell system;

FIG. **3**A is a diagrammatic representation of a network system in which a femtocell system implemented in accordance with an embodiment of the invention may be deployed;

FIG. **3**B is a diagrammatic representation of an alternative network system in which a femtocell system implemented in accordance with an embodiment of the invention may be deployed;

FIG. **4** is a simplified diagrammatic representation of femtocell system that facilitates provisioning of a femto-RAN in accordance with an embodiment;

FIG. **5** depicts a block diagram of a data processing system that may be implemented as a convergence server in accordance with an embodiment of the present invention;

FIG. **6** depicts a diagrammatic representation of a registration and authentication process on initial system access by a mobile station via a femtocell system in a non-Internet Protocol Multimedia Subsystem network implemented in accordance with an embodiment;

FIG. **7** depicts a diagrammatic representation of a registration and authentication process on initial system access by a mobile station via a femtocell system in an Internet Protocol Multimedia Subsystem network implemented in accordance with an embodiment;

FIG. **8** depicts a diagrammatic representation of an authentication center-initiated unique challenge process for a registered mobile station attached with a femtocell system in accordance with an embodiment;

FIG. **9**A is a diagrammatic representation of an authentication request message transmitted to a femtocell system from an authentication center implemented in accordance with an embodiment;

FIG. **9**B is a diagrammatic representation of an authentication response message transmitted from a femtocell system to an authentication center implemented in accordance with an embodiment;

FIG. **10** depicts a diagrammatic representation of an authentication center-initiated shared secret data key update process implemented in accordance with an embodiment;

FIG. **11**A is a diagrammatic representation of a shared secret data key update request message implemented in accordance with an embodiment and produced in response to an authentication center-initiated shared secret data key update;

FIG. **11**B is a diagrammatic representation of a shared secret data key update response message implemented in accordance with an embodiment;

FIG. **11**C is a diagrammatic representation of a base station challenge request message implemented in accordance with an embodiment;

FIG. **11**D is a diagrammatic representation of a base station challenge response message implemented in accordance with an embodiment;

FIG. **12** depicts a diagrammatic representation of an authentication center-initiated call history count update process implemented in accordance with an embodiment;

FIG. **13**A is a diagrammatic representation of a parameter update request message implemented in accordance with an embodiment; and

FIG. **13**B is a diagrammatic representation of a parameter update response message implemented in accordance with an embodiment.

## DETAILED DESCRIPTION OF THE INVENTION

It is to be understood that the following disclosure provides many different embodiments or examples for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting.

FIG. **1** is a diagrammatic representation of a network system **100** that includes a cellular network **110** adapted to provide macro-cellular coverage to a mobile station. Cellular network **110** may comprise, for example, a code-division multiple access (CDMA) network, such as a CDMA-2000 network.

Cellular network **110** may include any number of base transceiver stations (BTSs) **112***a*-**112***c* communicatively coupled with a base station controller (BSC) **114** or RNC. Each individual BTS **112***a*-**112***c* under the control of a given BSC may define a radio cell operating on a set of radio channels thereby providing service to an MS **125**, such as a mobile terminal. BSC **114** manages the allocation of radio channels, receives measurements from mobile terminals, controls handovers, as well as various other functions as is understood. BSC **114** is interconnected with a Mobile Switching Center (MSC) **116** that provides mobile terminal exchange services. BSC **114** may be additionally coupled with a packet data serving node (PDSN) **118** or other gateway service that provides a connection point between the CDMA radio access network and a packet network, such as Internet **160**, and provides mobility management functions and packet routing services. MSC **116** may communicatively interface with a circuit switched network, such as the public switched telephone network (PSTN) **150**, and may additionally be communicatively coupled with an interworking function (IWF) **122** that provides an interface between cellular network **110** and PSTN **150**.

System **100** may also include a signaling system, such as a signaling system #7 (SS7) network **170**. SS7 network **170** provides a set of telephony signaling protocols which are used to set up the vast majority of the world's PSTN telephone calls. SS7 network **170** is also used in cellular networks for circuit switched voice and packet-switched data applications. As is understood, SS7 network **170** includes various signaling nodes, such as any number of service control points (SCPs) **172**, signal transfer points (STPs) **174**, and service switching points (SSPs) **176**.

BTSs **112***a*-**112***c* deployed in cellular network **110** may service numerous network **110** subscribers. Cell cites provided by BTSs **112***a*-**112***c* commonly feature site ranges of a quarter to a half mile, e.g., in densely populated urban areas, to one to two miles in suburban areas. In other remotely populated regions with suitable geography, site ranges may span tens of miles and may be effectively limited in size by the limited transmission distance of relatively low-powered MSs. As referred to herein, a cell provided by a BTS deployed in carrier network **110** for access by any authorized network **110** subscriber is referred to as a macrocell.

FIG. **2** is a diagrammatic representation of a conventional network system **200** configuration featuring a femtocell. In the depicted example, a central BSC **214** deployed in a cellular carrier network **210** may connect with a soft switch core **212** that is connected with a MSC **216**. MSC **216** connects with the cellular core network and may interface with other networks, such as the PSTN as is understood. BSC **214** may be connected with and service numerous BTSs **212***a*-**212***c* that provide macrocells to cellular network **210** subscribers.

BSC **214** may additionally connect with a tunnel gateway system **218** that is adapted to establish secured tunnels **232***a*-**232***x* with respective femtocell systems **250***a*-**250***x*. Femtocells comprise cellular access points that connect to a mobile operator's network using, for example, a residential Digital Subscriber Line (DSL) or cable broadband connection. Fem-

tocells **250***a*-**250***x* provide a radio access point for MS **225** when the MS is within range of a femtocell system with which the MS has authorized access. For example, femtocell system **250***a* may be deployed in a residence of the user of MS **225**. Accordingly, when the user is within the residence, mobile telecommunications may be provided to MS **225** via an air-interface provided by femtocell system **250***a*. In this instance, MS **225** is effectively offloaded from the macro BTS, e.g., BTS **212***a*, and communications to and from the MS are carried out with femtocell system **250***a* over Internet **260**. Thus, femtocell systems **250***a*-**250***x* may reduce the carrier radio resource demands by offloading MSs from macrocells to femtocells and thereby provide for increased subscriber capacity of cellular network **210**.

In contemporary implementations such as that depicted in FIG. **2**, a femtocell system **250***a* comprises a transceiver without intelligence and is thus required to be connected and managed by BSC **214**. Thus, femtocell systems **250***a*-**250***x* are reliant on the carrier network centralized BSC **214** which has limited capacity and thus does not exhibit desirable scaling characteristics or capabilities. Moreover, high communications overhead are realized by the BTS backhaul.

FIG. **3**A is a diagrammatic representation of a network system **300** in which a femtocell system implemented in accordance with an embodiment of the invention may be deployed. System **300** includes a mobile core network **310** implemented as, for example, a code division multiple access (CDMA) core network that interfaces with a SS7 network **370**. Mobile core network **310** may include a Messaging Center (MC) **312**, a Home Location Register (HLR) **314**, an authentication center (AC) **315**, a Mobile Switching Center (MSC) **316**, a Packet Data Serving Node (PDSN) **318**, and various other components. The HLR **314** is a central database that contains details of each MS subscriber authorized to use the mobile core network **310**. There may be several HLRs deployed in the core network **310**. The HLR **314** maintains details of each Subscriber Identity Module (SIM) card issued by the mobile network operator, e.g., the International Mobile Subscriber Identity (IMSI) stored in the SIM card, services authorized for the associated user, a location of the MS, and various other information. The HLR **314** may interface with the AC **315** that functions to facilitate authentication of MSs that access the cellular network. The MSC **316** provides mobile terminal exchange services and may communicatively interface with a circuit switched network, such as the public switched telephone network. The MSC **316** handles voice calls and Short Message Service (SMS), sets up and releases end-to-end connections, and handles mobility and hand-over requirements during calls as well as other functions. The PDSN **318** provides an interface between the radio access and IP networks. The PDSN **318** provides, for example, mobility management functions and packet routing functionality.

System **300** includes an Internet Protocol (IP) core network **320** that interfaces with the SS7 network **370**, e.g., via IS-41. In accordance with an embodiment, the IP core network **320** includes a convergence server (CS) **322**, a softswitch/Media Gateway Controller Function (MGCF) **324**, and a Media Gateway (MGW) **326** among other components. The CS **322** may be communicatively coupled with the SS7 network **370** and a Packet Data Interworking Function (PDIF) **332**, e.g., via Session Initiation Protocol (SIP) communications. The CS **322** provides SIP registration functions and a central interface point to Voice over Internet Protocol (VoIP) elements and the softswitch/MGCF **324**. The CS **322** further provides SIP-MSC and Interworking functions between existing VoIP network elements and the operator's core network. To this end, the CS **322** may interface directly with the MC **312** and the HLR **314** using, for example, a TIA-41 interface.

The softswitch/MGCF **324** may be communicatively coupled with the CS **322**, e.g., via SIP communications, with the SS7 network **370**, and with the MGW **326**. The softswitch/MGCF **324** may connect calls from one device to another and perform call control protocol conversion, for example, between SIP and ISDN User Part (ISUP). The MGW **326** may be communicatively coupled with the SS7 network **370** and the PDIF **332** in addition to the softswitch/MGCF **324**. The MGW **326** may convert data between real-time transport protocol (RTP) and pulse code modulation (PCM), and may also be employed for transcoding. Resources of the MGW **326** may be controlled by the softswitch/MGCF **324**.

In accordance with an embodiment, the system **300** may include a Security Server (SS) **330** that interfaces with the SS7 network **370**, e.g., via IS-41, and the PDIF **332**, e.g., via a Wm interface. The PDIF **332** facilitates access to the IP core network **320** via WiFi access points and may be responsible for such services as, for example, security, access, authentication, policy enforcement, user information collection, and IP address allocation as well as other services. The PDIF **332** may interface, e.g., via SIP communications, with the CS **322**, and may have Real-time Transport Protocol (RTP) communications with the MGW **326**. Further, the PDIF **332** may have secured IP communications, e.g., IPsec, established with one or more femtocell systems, e.g., a femtocell system **350** deployed at a user premise, such as a home office. The secured communications may be established between the PDIF **332** and the femtocell system **350** over, for example, a broadband network **360** interface such as a residential DSL or cable broadband connection. The femtocell system **350**, in turn, provides a radio access point for one or more MSs **325** when the MS **325** is within range of the femtocell system **350** with which the MS **325** has authorized access.

In accordance with an embodiment, a femtocell system **350** may include integrated BTS and BSC functions and may feature additional capabilities available in the provided femtocell site coverage area. Femtocell system **350** provides an IP-accessible radio access network, is adapted for operation with IP core network **320**, and provides radio link control functions. Femtocell system **350** may be communicatively coupled with broadband network **360** via any variety of backhaul technologies, such as an 802.11x link, a 10/100 BaseT LAN link, a T1/E1 Span or fiber, cable set top box, DSL modem connected with a central office digital subscriber line access multiplexer, a very small aperture terminal (VSAT), or another suitable backhaul infrastructure.

In an embodiment, femtocell system **350** includes a session initiation protocol (SIP) adapter that supports a SIP client pool and provides conversion of call set-up functions to SIP client set-up functions. To this end, the femtocell system **350** may be allocated an IP address. Additionally, femtocell system **350** includes electronic serial number (ESN) screening and/or Mobile Equipment Identifier (MEID) screening to allow only designated MSs to access the femtocell. Configuration of the femtocell system **350** with ESN(s) or MEID(s) may be made as part of an initial femtocell system **350** activation.

In another embodiment, a femtocell system **350** may be implemented as a 3G-compliant entity, e.g., to service UMTS mobile terminals, and may be deployed in a small office/home office (SOHO) or other suitable enterprise. To this end, the femtocell system **350** may include an integrated RNC and radio node (RN). In a particular implementation, the femto-

cell system **350** may be implemented as an Evolution-Data Optimized (EV-DO) entity, e.g., a 1xEV-DO integrated IP-RAN. The femtocell system **350** provides an IP-accessible radio access network and provides radio link control functions.

FIG. **3**B is a diagrammatic representation of an alternative network system **301** in which a femtocell system implemented in accordance with an embodiment of the invention may be deployed. System **301** includes a mobile core network **310** implemented as, for example, a CDMA core network that interfaces with a SS7 network **370**. The mobile core network **310** may include an MC **312**, an HLR **314**, an AC **315**, an MSC **316**, and a PDSN **318**, and various other components as described above with regard to the mobile core network **310** of FIG. **3**A.

System **301** includes an IP Multimedia Subsystem (IMS) core network **321** that interfaces with the SS7 network **370**. In accordance with an embodiment, the IMS core network **321** includes a CS **322**, a MGCF **325**, an MGW **326**, an X-Call Session Control Function (X-CSCF) **328**, and a Home Subscriber Server (HSS) **329** among other components. The X-CSCF **328** processes SIP signaling packets and provides a centralized interface for control and signaling including SIP registration functions in accordance with disclosed embodiments. The X-CSCF **328** may provide Interrogating-CSCF (I-CSCF) services, Proxy-CSCF (P-CSCF) services, and Serving-CSCF (S-CSCF) services. The X-CSCF **328** comprises various SIP servers or proxies that process SIP signaling packets in the IMS core network **321**. P-CSCF services provided by X-CSCF may include provisioning a first point of contact for an IMS-compliant MS. In such a situation, the X-CSCF may be located in a visited network or in an MS's home network if the visited network is not fully IMS-compliant. An MS may discover the X-CSCF **328**, e.g., by using Dynamic Host Configuration Protocol (DHCP), or by assignment in a packet data protocol context. S-CSCF services provided by the X-CSCF **328** include provisioning as a central node of the signaling plane. To this end, the S-CSCF comprises a SIP server, but additionally performs session control. Further, the X-CSCF **328** is interfaced with the HSS **329** and/or HLR **314** to download and upload user profiles for providing S-CSCF services. The X-CSCF **328** further includes a SIP function for providing I-CSCF services. To this end, the X-CSCF **328** has an IP address that is published in the Domain Name System (DNS) that facilitates location of the X-CSCF **328** by remote servers. Thus, I-CSCF services of the X-CSCF **328** may be used as a forwarding point for receipt of SIP packets within the domain.

The CS **322** may be configured to operate as an IMS application server that interfaces with the X-CSCF **328** using the ISC interface. The HSS **329** comprises a user database that supports IMS network entities that manage or service calls. The HSS **329** contains subscription-related information, e.g., subscriber profiles, may perform authentication and authorization of users, and may provide information about locations of MSs and IP information. In a fully standard IMS architecture, the CS **322** may interface with the HSS **329**. However, in other scenarios, the HLR **314** may anchor the service even with the HSS **329** deployed within the system **301**. Accordingly, the CS **322** may be communicatively interfaced with the HLR **314** for location updates using, for example, a TIA-41 interface. Further, the CS **322** is preferably interfaced with the MC **312** using, for example, a TIA-41 interface.

The CS **322** may be communicatively coupled with the SS7 network **370**, the MGCF **325**, e.g., via SIP communications, the X-CSCF **328**, e.g., via ISC, and the HSS **329**, e.g., via an Sh interface. The MGCF **325** may be communicatively coupled with the MGW **326**, e.g., via an Mn interface, the X-CSCF **328**, e.g., via an Mg interface, and the SS7 network **370** in addition to the CS **322**. The MGW **326** may be communicatively coupled with the SS7 network **370** and a PDIF **332** in addition to the MGCF **325**. The MGW **326** may convert data between RTP and PCM, and may also be employed for transcoding. Resources of the MGW **326** may be controlled by the MGCF **325**. The X-CSCF **328** may be communicatively coupled with the PDIF **332** for exchanging SIP communications therewith and the HSS **329**, e.g., via a Cx interface, in addition to the CS **322** and the MGCF **325**. The HSS **329** may be communicatively coupled with the SS7 network **370**, e.g., via IS-41, and a SS **330**, e.g., via a Wx interface. The SS **330** may be coupled with the PDIF **332**, e.g., via a Wm interface.

The PDIF **332** facilitates access to the IMS core network **321** via WiFi access points and may be responsible for such services as, for example, security, access, authentication, policy enforcement, user information collection, and IP address allocation as well as other services. The PDIF **332** may have RTP communications with the MGW **326**. Further, the PDIF **332** may have secured IP communications, e.g., IPsec, established with one or more femtocell systems, e.g., a femtocell system **350** deployed at a user premise, such as a home office. The secured communications may be established between the PDIF **332** and the femtocell system **350** over, for example, a broadband network **360** interface such as residential DSL or cable broadband connection. The femtocell system **350**, in turn, provides a radio access point for one or more MSs **325** when the MS **325** is within range of the femtocell system **350** with which the MS **325** has authorized access.

FIG. **4** is a simplified diagrammatic representation of femtocell system **350** that facilitates provisioning of a femto-RAN in accordance with an embodiment. Femtocell system **350** includes an antenna **410** coupled with a RN **412**. RN **412** may be implemented, for example, as a 1xEV-DO ASIC device for provisioning a 1xEV-DO Rev. 0 air interface or a 1xEV-DO Rev. A air interface. RN **412** may be communicatively coupled with a RNC **414** that provides radio control functions, such as receiving measurements from MSs, control of handovers to and from other femtocell systems, and may additionally facilitate handoff to or from macrocells. RNC **414** may also provide encryption/decryption functions, power, load, and admission control, packet scheduling, and various other services.

Femtocell system **350** includes an electronic serial number screening function **416** that may facilitate approving or rejecting service for an MS by femtocell system **350**. Additionally, femtocell system **350** includes an Internet Operating System (IOS) and SIP Adapter (collectively referred to as IOS-SIP Adapter **418**). IOS-SIP adapter **418** may invoke and manage SIP clients, such as a user agent (UA) pool comprising one or more UAs. Each MS authorized to be serviced by femtocell system **350** may have a UA allocated therefor by femtocell system **350** in a manner that facilitates transmission of communications to and from an MS over an IP backhaul. Accordingly, when an authorized MS is within the femtocell system **350** site range, telecommunication services may be provided to the MS via the IP backhaul and the femtocell system **350** provisioned RAN. When the MS is moved beyond the service range of femtocell system **350**, telecommunication service may then be provided to the MS via macrocellular coverage. Femtocell system **350** may perform a DNS/ENUM registration on behalf of MSs authorized to obtain service from

femtocell system **350** and may generate and issue a SIP registration on behalf of an MS authorized for service access by the femtocell system **350**.

FIG. **5** depicts a block diagram of a data processing system that may be implemented as a convergence server **322** in accordance with an embodiment of the present invention. CS **322** may be a symmetric multiprocessor (SMP) system including a plurality of processors **502** and **504** connected to a system bus **506**. Alternatively, a single processor system may be employed. Also connected to system bus **506** is memory controller/cache **508** which provides an interface to local memory **509**. An I/O bus bridge **510** is connected to system bus **506** and provides an interface to an I/O bus **512**. Memory controller/cache **508** and I/O bus bridge **510** may be integrated as depicted.

Peripheral component interconnect (PCI) bus bridge **514** connected to I/O bus **512** provides an interface to PCI local bus **516**. A number of modems may be connected to a PCI local bus **216**. Communication links to clients may be provided through a modem **518** and network adapter **520** connected to PCI local bus **516** through add-in connectors.

Additional PCI bus bridges **522** and **524** provide interfaces for additional PCI local buses **526** and **528**, from which additional modems or network adapters may be supported. In this manner, server **322** allows connections to multiple system nodes. A memory-mapped graphics adapter **530** and hard disk **532** may also be connected to I/O bus **512** as depicted, either directly or indirectly.

Those of ordinary skill in the art will appreciate that the hardware depicted in FIG. **5** may vary. For example, other peripheral devices, such as optical disk drives and the like, also may be used in addition to or in place of the hardware depicted. The depicted example is not meant to imply architectural limitations with respect to the present invention.

While the CS **322** depicted in FIG. **5** comprises an SMP system, it should be understood that any variety of server configurations and implementations may be substituted therefor. The depicted server **322** is provided only to facilitate an understanding of disclosed embodiments, and the configuration of the CS **322** is immaterial with regard to the disclosed embodiments.

In many CDMA networks, a subscriber is uniquely identified by the combination of an electronic serial number (ESN) and a mobile identification number (MIN). A mobile equipment identifier (MEID) is an extension of the ESN that facilitates an increase in the number of manufacturers' codes. A pseudo-ESN (p-ESN) may be derived from the MEID to be used in place of the ESN. The MIN-ESN, or MIN-p-ESN, combination is used primarily for registration and authentication functions. Contemporary CDMA MSs may support an international mobile station identity (IMSI) and use the IMSI in place of the MIN to offer an improved address space and utilization by international applications. With the introduction of IMSI, the concept of a mobile station identity may be either an MIN or an IMSI. Due to the variations in different parameters for identification, it is assumed herein that a unique identifier is included in the username portion of the To Header of a SIP:REGISTER request to create and identify the mobile station subscriber during the registration procedures described hereinbelow. This unique identifier is referred to herein as the register ID (RegID). An optional network dependent predefined prefix may be stripped from the register ID prior to use in the convergence server functions. The register ID may contain an MIN or an IMSI paired with either an MEID, an ESN, or a p-ESN. However, other options may be suitably implemented without departing from the disclosed embodiments.

In accordance with an embodiment, the CS **322** emulates the functionality of a MSC and Visitor Location Register (VLR) to facilitate authentication and registration of MSs in a carrier's CDMA network. To this end, the CS **322** may interface with the HLR **314** for authentication, location updates, and other services using an IS-41 interface.

In a pre-IMS environment, e.g., such as network system **300** depicted in FIG. **3**A, the CS **322** receives a SIP:REGISTER message directly from the femtocell system **350**, or from the femtocell system **350** acting as a proxy for the MS **325**. The CS **322** provides SIP registration functions and is the central interface point to the softswitch/MGCF **324** and VoIP elements.

In an IMS network such as network system **301** depicted in FIG. **3**B, the CS **322** functions as an IMS application server, and the IMS infrastructure provides the centralized interface control and signaling including SIP registration functions. In this environment, the femtocell system **350** itself, or alternatively the femtocell system **350** acting as a proxy for the MS **325**, sends a SIP:REGISTER (e.g., via other CSCFs) to the S-CSCF which performs a third-party registration of the MS **325** with the CS **322** based on initial filter criteria stored in the HSS **329**.

In an embodiment, the femtocell system **350** may be configured to support "Global Challenge" based authentication on all system access (e.g., Registration, Call Origination, Call Termination, and Data Burst messages). The femtocell system may indicate a Global Challenge request by setting an authentication bit (e.g., AUTH=1) in the overhead message train (OMT). The femtocell system **350** may also include a global random challenge value (RAND) used in generating the authentication result by both the MS and the HLR/AC.

The femtocell system preferably establishes an IPsec tunnel over the broadband network with the PDIF **332** or, alternatively, a P-CSCF before sending any SIP traffic to the CS **322**. The IPsec tunnel may be established immediately after the femtocell system **350** is powered on or when an MS **325** attempts to establish a connection with the femtocell system **350**. In this implementation, the CS **322** is not involved in establishing the IPsec tunnel.

In an embodiment, the CS **322** may be configured to receive CDMA-1x authentication data at the end of a SIP registration message using a SIP:MESSAGE received from the femtocell system **350**. In this manner, the CS **322** conveys the result of the 1x authentication and, if needed, performs various authentication procedures, such as a unique challenge, SSD update, and a call history count.

FIG. **6** depicts a diagrammatic representation of a registration and authentication process **600** on initial system access by an MS via a femtocell system in a non-IMS network, such as network system **300** depicted in FIG. **3**A, implemented in accordance with an embodiment. A SIP registration phase is invoked by transmission of an OMT by the femtocell system **350** (step **602**). An OMT facilitates autonomous registration and may, for example, be transmitted on paging/access channels. Transmission of the OMT by the femtocell system **350** may be made at a predefined interval, e.g., once a second. The OMT may include parameters for system and region identification and may be distinguished from OMTs transmitted by other entities, e.g., by macro BTSs. An MS **325** in idle mode may detect the OMT when the MS **325** is within range of the femtocell system **350**. In accordance with an embodiment, the OMT transmitted by the femtocell system **350** includes an authentication bit (AUTH) having a value, e.g., "1", that indicates authentication is required for all system access. Further, the OMT includes a random number (RAND) generated by the femtocell system **350**.

Based on the values in the OMT, the MS determines that a new serving system has been encountered and that authentication is required based on the authentication bit value (AUTH=1). Subsequently, the MS **325** attempts to obtain the random number (RAND) to be used for the authentication from the OMT. If the random number is not available, a zero value may be used by the MS as prescribed by TR-45 authentication procedures. The MS **325** then generates an authentication result (AUTHR). For example, the MS **325** may generate an authentication result from a shared secret data key (SSD-A) stored by the MS **325**, the ESN or p-ESN, the MIN, and the RAND value obtained from the OMT. The authentication result may be generated, for example, by execution of the well known CAVE algorithm by the MS **325**. The MS then transmits a registration request to the femtocell system **350** (step **604**). The register message may include the MS's MIN, ESN or p-ESN, the authentication result (AUTHR), a CallHistoryCount (COUNT), and a random confirmation (RANDC) derived from the random number (RAND) used to compute the authentication result (AUTHR).

On receiving the registration request from the MS **325**, the femtocell system **350** sends a SIP:REGISTER message to the CS **322** (step **606**) in accordance with an embodiment that includes the unique register ID associated with the MS, e.g., derived from an MIN or an IMSI paired with either an MEID, an ESN, or a p-ESN.

Optionally, the femtocell system **350** may establish an IPsec tunnel with the PDIF **332**. The CS **322** then acknowledges receipt of the SIP:REGISTER message by transmitting a 200 OK SIP response to the femtocell system **350** (step **608**).

A registration phase is then invoked by the femtocell system **350** transmitting 1x authentication parameters received from the MS **325** at step **604** to CS **322** in a SIP: MESSAGE (LOCATION_UPDATING_REQUEST) (step **610**). The location updating request message includes the random number (RAND) rather than the random number confirmation (RANDC). The location updating request message additionally may include parameters, such as a Register ID, ESN, MEID, MIN, IMSI, etc. Using the Register ID, the CS **322** may associate the location updating request with the preceding SIP:REGISTER request received thereby from the femtocell system **350** in step **606**. If the location updating request message includes a P-Access-Network-Info (PANI) header that may specify information about the access technology, the CS **322** may save the PANI information.

The CS **322** acknowledges receipt of the location updating request message by transmitting a 200 OK SIP response to the femtocell system **350** (step **612**). Network authentication and registration then occurs via exchanges between the CS **322** and HLR/AC (step **614**). As part of the authentication response, the HLR/AC may trigger Unique Challenge, SSD update, or CountUpdate procedures.

The CS **322** informs the femtocell system **350** of the authentication and registration results by transmitting a SIP location updating response message to the femtocell system **350** (step **616**). In the event of an authentication or registration failure, the CS **322** may send a SIP:MESSAGE containing, for example, an XML-encoded message body that facilitates deregistration of the femtocell system **350**. The femtocell system **350** acknowledges receipt of the authentication and registration results by sending a 200 OK SIP response to the CS **322** (step **618**). In the event of either a registration or authentication failure, a deregistration process **630** is invoked by the femtocell system **350** transmitting a deregistration message, e.g., a SIP: REGISTER message with an expire value "0", to the CS **322** (step **620**). The CS **322** acknowledges receipt of the deregistration message by transmitting a 200 OK SIP response to the femtocell system **350** (step **622**).

FIG. **7** depicts a diagrammatic representation of a registration and authentication process **700** on initial system access by an MS via a femtocell system in an IMS network, such as network system **301** depicted in FIG. **3**B, implemented in accordance with an embodiment. In this implementation, it is assumed that the MS comprises a standard 1x mobile phone and the femtocell system **350** is configured to operate as an IMS client on behalf of the mobile stations attached with the femtocell system **350**. When an MS attempts to establish a connection with the femtocell system **350**, the femtocell system **350** first attempts to register in the IMS network on behalf of the MS. As part of the registration, the IMS network may perform IMS-AKA authentication or, alternatively, allow the registration without performing any authentication. Further, in the described implementation, it is assumed that the CS **322** is configured to act as an application server (AS) in the IMS domain, and that it receives 3rd-party registration requests from the S-CSCF at the end of the IMS network registration process.

The femtocell system **350** transmits an OMT (step **702**) at a predefined interval. An MS **325** in idle mode may detect the OMT when the MS **325** is within range of the femtocell system **350** as described above with reference to FIG. **3**A. The OMT transmitted by the femtocell system **350** may include an authentication bit (AUTH) having a value, e.g., "1", that indicates authentication is required for all system access, and a random number (RAND) generated by the femtocell system **350**. On receipt of the OMT, the MS determines that a new serving system has been encountered and that authentication is required based on the authentication bit value (AUTH=1). Subsequently, the MS **325** attempts to obtain the random number (RAND) to be used for the authentication from the OMT. If the random number is not available, a zero value may be used by the MS as prescribed by TR-45 authentication procedures. The MS **325** then generates an authentication result (AUTHR), and transmits a registration request to the femtocell system **350** (step **704**). The registration message may include the MS's MIN, ESN or p-ESN, the authentication result (AUTHR), a CallHistoryCount (COUNT), and a random number confirmation (RANDC) derived from the random number (RAND) used to compute the authentication result (AUTHR).

An IMS registration phase **730** is then initiated by the femtocell system **350** sending a registration request to the S-CSCF (step **706**). The S-CSCF then sends a 3rd-party registration request to the CS **322** (step **708**), and the CS **322** returns a 200 OK SIP response to the S-CSCF (step **710**) for the 3rd-party registration which completes the IMS network registration.

If the registration fails, the CS **322** informs the femtocell system **350** to perform IMS network deregistration. Assuming the registration is successful, an authentication process is then invoked by the femtocell system **350** transmitting 1x authentication parameters received from the MS **325** at step **704** to CS **322** in a SIP: MESSAGE(LOCATION_UPDATING_REQUEST) (step **712**). The location updating request message includes the random number (RAND) rather than the random number confirmation (RANDC). The location updating request message additionally may include parameters, such as a Register ID, ESN, MEID, MIN, IMSI, etc. If the location updating request message includes a P-Access-Network-Info (PANI) header that may specify information about the access technology, the CS **322** saves the PANI information.

The CS **322** acknowledges receipt of the location updating request message by transmitting a 200 OK SIP response to the femtocell system **350** (step **714**). Network authentication and registration then occurs via exchanges between the CS **322** and HLR/AC (step **716**). As part of the authentication response, the HLR/AC may trigger Unique Challenge, SSD update, or CountUpdate procedures.

The CS **322** informs the femtocell system **350** of the authentication and registration results by transmitting a SIP location updating response message to the femtocell system **350** (step **718**). In the event of an authentication or registration failure, the CS **322** may send a SIP:MESSAGE containing, for example, an XML-encoded message body that facilitates deregistration of the femtocell system **350**. The femtocell system **350** acknowledges receipt of the authentication and registration results by sending a 200 OK SIP response to the CS **322** (step **720**).

In the event of either a registration or authentication failure, a deregistration process **740** is invoked by the femtocell system **350** transmitting a deregistration message, e.g., a SIP: REGISTER message with a expire value "0", to the S-CSCF (step **722**). The S-CSCF acknowledges receipt of the deregistration message by transmitting a 200 OK SIP response to the femtocell system **350** (step **724**). The S-CSCF then transmits the deregistration message to the CS **322** (step **726**) which acknowledges receipt of the deregistration message by transmitting a 200 OK SIP response to the S-CSCF (step **728**) thereby completing deregistration of the MS.

The CS **322** may receive a SIP:REGISTER message for a subscriber who is not currently SIP registered, but for whom the CS **322** maintains subscription data from the HLR. For example, the CS **322** may maintain the HLR subscription information for a configurable period after a SIP deregistration. In this scenario, a MS re-registration procedure may be invoked. The re-registration may be consistent with that as described above with reference to FIG. **6** except the CS **322** is not required to request the user profile from the HLR.

Periodic registration is optionally required in mobile networks. If periodic registration is enabled, the HLR may return an "Authorization Period" in response to a Registration Notification (REGNOT). In this case, the CS **322** may send a SIP:MESSAGE (ORDERED_REGISTRATION_REQUEST) before the "Authorization Period" expires. On receiving this request, the femtocell system **350** may send the ordered registration request to the MS **325** to send registration-related parameters.

Regardless of an "Authorization Period" timer, the SIP registration period dictates the interval at which the SIP registration from the femtocell system **350** needs to be refreshed. In such a case, the femtocell system **350** needs to refresh the registration prior to the expiration period while the MS **325** is attached to the femtocell system **350**. Such registration procedures are preferably processed locally at the CS **322**. The femtocell system **350** sends a SIP:REGISTER message to the CS **322**, and the CS **322** returns a SIP 200 OK response to the femtocell system **350**.

When deregistration occurs, e.g., either due to registration timeout or mobile-initiated/network deregistration, the CS **322** may typically not delete HLR subscriber data which is eligible to be aged out, or removed by a REGCANC message. The CS **322** may send a mobile station inactive (MSINACT) message to the HLR with the optional DeregistrationType parameter omitted which indicates that subscriber data is still being maintained by the CS **322**. Such a situation may occur, for example, due to the MS **325** being powered off and it is desirable to have the subscription data available when the MS is powered back on. However, the time the MS was last registered is maintained with the subscription data.

If the MS does not re-register for a configurable time (e.g., 24 hours), the subscriber data may be deleted and an MSINACT message is sent to the HLR with the DeregistrationType set to "administrative reason" indicating that the subscriber data has been purged from the CS **322**. This may also occur as needed to free up space in the database thereby deleting the oldest data first based on when it was last accessed.

A mobile initiated de-registration process may be invoked when the CS **322** receives a SIP:REGISTER from the femtocell system **350** with a timeout of zero for a current registration. In an IMS network, the CS **322** may receive this message from the S-CSCF as a 3rd-party SIP:REGISTER message. For example, such a de-registration may occur when the femtocell system **350** receives a power-down indication from the MS, the femtocell system **350** detects MS inactivity, or the femtocell system **350** detects a loss of radio contact.

Deregistration may additionally occur due to location updating. When the MS registers in a macrocell, the HLR preferably notifies the CS **322** accordingly. If the SIP registration for the corresponding MS is currently active, the CS **322** may send a SIP:MESSAGE (Deregister) to the femtocell system **350** requesting it to deregister. Registration cancellation may additionally occur due to administrative reasons as well. In such a case, the MS may be in a call or using some network service. If the cancellation indicates that service is to be discontinued immediately, the CS **322** terminates any call in progress.

FIG. **8** depicts a diagrammatic representation of an AC-triggered unique challenge process **800** for a registered MS attached with a femtocell system in accordance with an embodiment. Depending on the administrative policy at the AC **315**, the AC **315** may trigger a unique challenge process for a currently registered MS **325** at any time.

A unique challenge is initiated by the AC (step **802**) and is received by the CS **322**. The CS **322** sends a SIP: MESSAGE (AUTH_REQUEST) to the femtocell system **350** to initiate a unique authentication challenge (step **804**). The femtocell system **350** acknowledges receipt of the authentication challenge by transmitting a 200 Ok SIP response to the CS **322** (step **806**). Subsequently, the femtocell system **350** sends a unique challenge order to the MS (step **808**) that includes a pseudo-randomly generated value (RANDU). The MS then generates a authentication result (AUTHU), e.g., by invoking the well known CAVE algorithm using the RANDU and the SSD-A currently stored by the MS, the ESN or p-ESN of the MS, and the MIN**1** and MIN**2** to produce the authentication result (AUTHU). The authentication result is then transmitted from the MS **325** to the femtocell system **350** (step **810**). The femtocell system **350** forwards the authentication result to the CS **322**, e.g., using a SIP:MESSAGE (AUTH_RESPONSE) (step **812**). The CS **322** may acknowledge receipt of the authentication result by transmitting a 200 Ok SIP response to the femtocell system **350** (step **814**). An AC report may then be exchanged with the AC and CS **322** (step **816**).

FIG. **9**A is a diagrammatic representation of an authentication request message **900** transmitted to the femtocell system from the CS implemented in accordance with an embodiment. The authentication request message **900** transmitted to the femtocell system **350**, e.g., according to step **804** of FIG. **8**, may be generated by the CS **322** in response to an authentication challenge issued by the AC, e.g., according to step **802** of FIG. **8**. The authentication request message **900** may be implemented as a SIP message including the depicted XML-encoded authentication request message. In this imple-

mentation, a message ID (msgid) field **902** of the authentication request message **900** may be null or otherwise excluded from the authentication request message **900**. The CS **322** preferably invokes a timer response that specifies a maximum response time for the femtocell system **350** to return an authentication response submitted by the MS thereto. The CS **322** may, for example, invoke the timer after receiving the 200 OK response from the femtocell system **350** for the authentication request, e.g., according to step **806** of FIG. **8**. The timer is preferably stopped when the authentication response (AUTH_RESPONSE) message is received, e.g., according to step **812** of FIG. **8**. The authentication request message **900** preferably includes a registration field **904** that includes the identification, e.g., the Register ID (illustratively designated RegID-A) used during the SIP:REGISTER procedure (e.g., according to step **606** of FIG. **6** that may be derived from an MIN or an IMSI paired with either an MEID, an ESN, or a p-ESN) such that the femtocell system **350** can map the authentication process to the appropriate session in the case of an AC-initiated request. The authentication request message additionally may include the pseudo-randomly generated value (illustratively designated "3354C0") in a corresponding field **906**.

FIG. **9**B is a diagrammatic representation of an authentication response message **950** transmitted from the femtocell system **350** to the CS **322** implemented in accordance with an embodiment. The authentication response message **950** may be included in a SIP message including the depicted XML-encoded authentication response message.

The authentication response message **950** may be sent from the femtocell system **350** to the CS **322** to respond to a unique challenge, e.g., according to step **812** of FIG. **8**. The authentication response message preferably includes an authentication result field **952** that includes an authentication result ("AUTHU" illustratively designated "021AC3") that is provided to the femtocell system **350** from the MS. For example, the authentication result included in the authentication result field **952** may be generated by the MS executing an instance of the CAVE algorithm using RANDU and the SSD-A currently stored by the MS, the ESN/p-ESN, and the MIN**1** and MIN**2**.

FIG. **10** depicts a diagrammatic representation of an AC initiated SSD update process **1000** implemented in accordance with an embodiment. The AC **315** triggers a Shared Secret Data (SSD) update procedure, e.g., as a result of an administrative policy of the AC, an expiration of an authentication time interval at the AC, the report of a security violation from a visited system, or another trigger event (step **1002**). The CS **322** sends a SIP:MESSAGE(SSD_UPDATE_REQUEST) to the femtocell system **350** to initiate an SSD Update Order with the MS **325** (step **1004**). The femtocell system **350** acknowledges the receipt of the SSD update request message, e.g., by transmitting a 200 Ok SIP response to the CS **322** (step **1006**). The femtocell system **350** then sends an SSD Update Order message to the MS **325** (step **1008**). The MS **325** then produces a new value of the SSD, e.g., by executing the CAVE algorithm using the value of the random number seed (RANDSSD), e.g., a pseudo-randomly generated sequence, provided in the SSD Update order, the ESN or p-ESN, and the A-key. The MS selects a Random Number (RANDBS) and sends a Base Station Challenge order to the femtocell system **350** including the value of the selected RANDBS (step **1010**). The MS then executes the CAVE algorithm to produce an Authentication Result (AUTHBS) using the new value of SSD-A, the ESN or p-ESN, the MIN**1**, and the Random Number (RANDBS).

Upon receiving the Base Station Challenge order, the femtocell system **350** transmits a SIP:MESSAGE(BSCHALL_REQUEST) to the CS **322** (step **1012**), which acknowledges receipt thereof by transmitting a 200 Ok SIP response to the femtocell system **350** (step **1014**). A base station challenge is then initiated between the CS **322** and the HLR/AC (step **1016**). The CS **322** then sends a SIP: MESSAGE (BSCHALL_ RESPONSE) to the femtocell system **350** to forward the AUTHBS to the MS in a Base Station Challenge response message (step **1018**), and the femtocell system **350** acknowledges receipt of the base station challenge response by transmitting a 200 Ok SIP response to the CS **322** (step **1020**). The femtocell system **350** then sends a Base Station Challenge response along with the AUTHBS to the MS **325** (step **1022**). If the AUTHBS result provided by the AC **315** matches the value computed by the MS, the MS **325** stores the new SSD value for use in future executions of CAVE and sends an SSD Update Confirmation message to the femtocell system (step **1024**). Upon receiving the SSD Update Confirmation message, the femtocell system **350** sends a SIP:MESSAGE (SSD_UPDATE_RESPONSE) message to the CS **322** (step **1026**), and the CS **322** acknowledges receipt thereof, e.g., by transmitting a 200 Ok SIP response to the femtocell system (step **1028**).

The CS **322** then sends a SIP: MESSAGE(AUTH_REQUEST) to the femtocell system **350** to initiate a unique authentication challenge (step **1030**). The femtocell system **350** acknowledges receipt of the authentication challenge by transmitting a 200 Ok SIP response to the CS **322** (step **1032**). Subsequently, the femtocell system **350** sends a unique challenge order to the MS (step **1034**). The MS **325** then generates an authentication result (AUTHU), e.g., by invoking the well known CAVE algorithm using the RANDU and the SSD-A currently stored by the MS, the ESN or p-ESN of the MS, and the MIN**1** and MIN**2** to produce the authentication result (AUTHU). The authentication result is then transmitted from the MS **325** to the femtocell system **350** (step **1036**). The femtocell system **350** forwards the authentication result to the CS **322**, e.g., using a SIP:MESSAGE (AUTH_RESPONSE) (step **1038**). The CS **322** may acknowledge receipt of the authentication result by transmitting a 200 Ok SIP response to the femtocell system **350** (step **1040**). An AC report is then exchanged with the network, e.g., between the CS **322** and the HLR/AC (step **1042**).

FIG. **11**A is a diagrammatic representation of an SSD update request message **1100** implemented in accordance with an embodiment and produced in response to an AC initiated SSD update. The SSD update request message **1100** may be included in a SIP message including the depicted XML-encoded SSD update request message.

The SSD update request message **1100** may be transmitted from the CS **322** to the femtocell system **350** to update the shared secret data (SSD) stored at the MS, e.g., according to step **1004** of FIG. **10**. In an embodiment, the SSD update request message **1100** may include a message ID field **1102** that may be nulled or otherwise excluded from the SSD update request message **1100** in the event the SSD update is initiated by the AC. A maximum response timer may be invoked by the AC **322**, e.g., after receiving the 200 OK response according to step **1006** of FIG. **10** from the femtocell system for the SSD update request. The timer may be stopped when the BSC challenge request is received by the CS **322** according to step **1012** of FIG. **10**. The SSD update request message **1100** preferably includes a registration field **1104** that includes the MS identification, e.g., the Register ID (illustratively designated RegID-A) used during the SIP:REGISTER procedure (e.g., according to step **606** of FIG. **6** that

may be derived from an MIN or an IMSI paired with either an MEID, an ESN, or a p-ESN) such that the femtocell system **350** can map the authentication process to the appropriate session in the case of an AC-initiated SSD update request. The SSD update request message **1100** may additionally include a random seed value field **1106** that includes the random seed value (illustratively designated "D3568710A76E21")

FIG. **11**B is a diagrammatic representation of an SSD update response message **1120** implemented in accordance with an embodiment. The SSD update response message **1120** may be included in a SIP message including the depicted XML-encoded SSD update response message. The SSD update response **1120** is sent from the femtocell system **350** to the CS **322** to indicate the status of the SSD update according to step **1026** of FIG. **10**.

The CS **322** may invoke a timer for receipt of the SSD update response message **1120**, e.g., upon receipt of the 200 OK response for the BS challenge response according to step **1020** and may be stopped when an SSD update response message is received according to step according to step **1026**.

FIG. **11**C is a diagrammatic representation of a base station challenge request (BSCHALL_REQUEST) message **1140** implemented in accordance with an embodiment. The base station challenge request message **1140** is preferably transmitted from the femtocell system **350** to the CS **322** to perform a base station challenge, e.g., according to step **1012** of FIG. **10**. The base station challenge request message **1140** may be included in a SIP message including the depicted XML-encoded base station challenge request message.

In an embodiment, the base station challenge request message **1140** may include a message ID field **1142** that may be nulled or otherwise excluded from the base station challenge request message **1140** in the event the base station challenge request is initiated by the AC. The base station challenge request message may include a random number field **1144** that includes the random number (RANDBS) selected by the MS. A timer for response to the base station challenge request may be invoked, e.g., after receipt of the 200 OK response received by the femtocell system **350** from the CS **322** for the base station challenge request according to step **1014**. The timer is preferably stopped when the base station challenge response (BSCHALL_RESPONSE) is received by the femtocell system **350** from the CS **322** according to step **1018**.

FIG. **11**D is a diagrammatic representation of a base station challenge response (BSCHALL_RESPONSE) message **1160** implemented in accordance with an embodiment. The base station challenge response message **1160** is preferably transmitted from the CS **322** to the femtocell system **350**, e.g., according to step **1018** of FIG. **10**. The base station challenge response message **1160** may be included in a SIP message including the depicted XML-encoded base station challenge response message and includes an authentication result field **1162** that includes the authentication result produced by the authentication center.

In accordance with another embodiment, an AC-initiated CallHistoryCount (COUNT) Update may be performed. In this implementation, the AC triggers the CallHistoryCount update as a result of, for example, administrative procedures at the AC, the expiration of an authentication time interval at the AC, the report of a security violation from a visited system, or other trigger events.

FIG. **12** depicts a diagrammatic representation of an AC initiated CallHistoryCount update process **1200** implemented in accordance with an embodiment. A count update occurs by an exchange between the HLR/AC and the CS **322** (step **1202**). The CS **322** then transmits a SIP:MESSAGE (PARAMETER_UPDATE_REQUEST) to the femtocell system **350** to initiate the parameter update order to the MS **325** (step **1204**). The femtocell system **350** acknowledges receipt of the parameter update request message, e.g., by transmitting a 200 Ok SIP response to the CS **322** (step **1206**). The femtocell system **350** then sends the parameter update order to the MS **325** (step **1208**). The MS **325** increments its value of the CallHistoryCount and sends a confirmation to the femtocell system **350** (step **1210**). The femtocell system **350**, in turn, informs the CS **322** of the COUNT update confirmation by sending a SIP:MESSAGE (PARAMETER_UPDATE_RESPONSE) to the CS **322** (step **1212**) which acknowledges receipt of the parameter update response, e.g., by transmitting a 200 Ok SIP response to the femtocell system **350** (step **1214**). An AC report is then exchanged between the CS **322** and the network, e.g., the HLR/AC (step **1216**).

FIG. **13**A is a diagrammatic representation of a parameter update request message **1300** (PARAMETER_UPDATE_REQUEST) implemented in accordance with an embodiment. The parameter update request message **1300** is preferably transmitted from the CS **322** to the femtocell system **350** to request a call history count update, e.g., according to step **1204** of FIG. **12**. The parameter update request message **1300** may be included in a SIP message including the depicted XML-encoded parameter update request message.

The parameter update request message **1300** may include message ID filed **1302** that is nulled or otherwise excluded in the case of an AC-initiated update request. A maximum timer may be invoked for response to the parameter update request by the CS **322**, e.g., upon receipt of the 200 OK response from the femtocell system **350** according to step **1206** of FIG. **12**. The timer may be stopped when the parameter update response (PARAMETER_UPDATE_RESPONSE) is received by the CS **322**, e.g., according to step **1212** of FIG. **12**. The parameter update request message **1300** preferably includes a registration field **1304** that includes the MS identification, e.g., the Register ID (illustratively designated RegID-A) used during the SIP:REGISTER procedure (e.g., according to step **606** of FIG. **6** that may be derived from an MIN or an IMSI paired with either an MEID, an ESN, or a p-ESN) such that the femtocell system **350** can map the parameter update process to the appropriate session in the case of an AC-initiated update process.

FIG. **13**B is a diagrammatic representation of a parameter update response message **1350** (PARAMETER_UPDATE_RESPONSE) implemented in accordance with an embodiment. The parameter update response message is preferably transmitted from the femtocell system **350** to the CS **322**, e.g., according to step **1212** of FIG. **12**, to return the results of a parameter update request. The parameter update response message **1350** may be included in a SIP message including the depicted XML-encoded parameter update response message. The parameter update response message preferably includes a successful update field **1352** that includes a value, e.g., a Boolean True or False value that specifies whether the parameter update was successfully or unsuccessfully performed.

As described, mechanisms for facilitating authentication center-initiated authentication procedures for a mobile station attached with a femtocell system are provided. A femtocell system may generate a registration identification of a mobile station from one or more mobile station authentication parameters. A convergence server located in a core network receives an authentication procedure request from an authentication center for the mobile station attached with the femtocell system and generates an authentication procedure request message that includes the registration identifier assigned to the mobile station. The convergence server then

transmits the authentication procedure request message to the femtocell system and receives a response to the authentication procedure request message from the femtocell system. In an embodiment, the authentication procedure request comprises a unique challenge. In another embodiment, the authentication procedure request comprises a shared secret data update procedure. In yet another embodiment, the authentication procedure request comprises a call history count update procedure.

The illustrative block diagrams depict process steps or blocks that may represent modules, segments, or portions of code that include one or more executable instructions for implementing specific logical functions or steps in the process. Although the particular examples illustrate specific process steps or procedures, many alternative implementations are possible and may be made by simple design choice. Some process steps may be executed in different order from the specific description herein based on, for example, considerations of function, purpose, conformance to standard, legacy structure, user interface design, and the like.

Aspects of the present invention may be implemented in software, hardware, firmware, or a combination thereof. The various elements of the system, either individually or in combination, may be implemented as a computer program product tangibly embodied in a machine-readable storage device for execution by a processing unit. Various steps of embodiments of the invention may be performed by a computer processor executing a program tangibly embodied on a computer-readable medium to perform functions by operating on input and generating output. The computer-readable medium may be, for example, a memory, a transportable medium such as a compact disk, a floppy disk, or a diskette, such that a computer program embodying the aspects of the present invention can be loaded onto a computer. The computer program is not limited to any particular embodiment, and may, for example, be implemented in an operating system, application program, foreground or background process, driver, network stack, or any combination thereof, executing on a single processor or multiple processors. Additionally, various steps of embodiments of the invention may provide one or more data structures generated, produced, received, or otherwise implemented on a computer-readable medium, such as a memory.

Although embodiments of the present invention have been illustrated in the accompanied drawings and described in the foregoing description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions without departing from the spirit of the invention as set forth and defined by the following claims. For example, the capabilities of the invention can be performed fully and/or partially by one or more of the blocks, modules, processors or memories. Also, these capabilities may be performed in the current manner or in a distributed manner and on, or via, any device able to provide and/or receive information. Further, although depicted in a particular manner, various modules or blocks may be repositioned without departing from the scope of the current invention. Still further, although depicted in a particular manner, a greater or lesser number of modules and connections can be utilized with the present invention in order to accomplish the present invention, to provide additional known features to the present invention, and/or to make the present invention more efficient. Also, the information sent between various modules can be sent between the modules via at least one of a data network, the Internet, an Internet Protocol network, a wireless source, and a wired source and via plurality of protocols.

What is claimed is:

**1**. A method, comprising:

receiving, by a convergence server located in a core network, an authentication procedure request from an authentication center for a mobile station attached with a femtocell system;

generating, by the convergence server, an authentication procedure request message that includes a registration identifier assigned to the mobile station, the registration identifier comprising a pseudo-electronic serial number derived from a mobile equipment identifier for the mobile station;

transmitting, by the convergence server, the authentication procedure request message to the femtocell system; and

receiving, by the convergence server, a response to the authentication procedure request message from the femtocell system;

wherein the authentication procedure request comprises a unique challenge, and

wherein the authentication procedure request message comprises an authentication request that includes a pseudo-randomly generated value;

wherein the response includes an authentication result generated by the mobile station using the pseudo-randomly generated value and a shared secret data key.

**2**. The method of claim **1**, wherein the femtocell system maps the authentication procedure to the mobile station using the registration identifier.

**3**. The method of claim **1**, wherein the authentication procedure request comprises a shared secret data update procedure, and wherein the authentication procedure request message comprises a shared secret data update request message.

**4**. The method of claim **3**, further comprising transmitting, by the femtocell system, an update order to the mobile station that includes a random number seed.

**5**. The method of claim **4**, further comprising receiving, by the convergence server, a base station challenge request message from the femtocell system including a pseudo-random value selected by the mobile station.

**6**. The method of claim **5**, further comprising:

engaging, by the convergence server, the authentication center in a base station challenge process; and

transmitting, by the convergence server, a base station challenge response to the femtocell system including a base station authentication result received from the authentication center.

**7**. The method of claim **6**, further comprising updating, by the mobile station, a shared secret data key in the event the base station authentication result in the base station challenge response matches a base station authentication result produced by the mobile station.

**8**. The method of claim **1**, wherein the authentication procedure request comprises a call history count update procedure, and wherein the authentication procedure request message comprises a count update message.

**9**. A non-transitory computer-readable medium having computer-executable instructions tangibly embodied thereon for execution by a processing system, the computer-executable instructions, when executed, cause the processing system to:

receive, by a convergence server located in a core network, an authentication procedure request from an authentication center for the mobile station attached with the femtocell system;

generate, by the convergence server, an authentication procedure request message that includes a registration identifier assigned to the mobile station, the registration

identifier comprising a pseudo-electronic serial number derived from a mobile equipment identifier for the mobile station;

map the authentication procedure to the mobile station using the registration identifier;

transmit, by the convergence server, the authentication procedure request message to the femtocell system; and

receive, by the convergence server, a response to the authentication procedure request message from the femtocell system;

wherein the authentication procedure request comprises a unique challenge, the authentication procedure request message comprises an authentication request that includes a pseudo-randomly generated value, and the response includes an authentication result generated by the mobile station using the pseudo-randomly generated value and a shared secret data key.

**10**. The non-transitory computer-readable medium of claim **9**, wherein the authentication procedure request comprises a shared secret data update procedure and the authentication procedure request message comprises a shared secret data update request message, the non-transitory computer-readable medium further comprising instructions that, when executed by the processing system, cause the processing system to transmit, by the femtocell system, an update order to the mobile station that includes a random number seed.

**11**. The non-transitory computer-readable medium of claim **10**, further comprising instructions that, when executed by the processing system, cause the processing system to:

receive, by the convergence server, a base station challenge request message from the femtocell system including a pseudo-random value selected by the mobile station;

engage, by the convergence server, the authentication center in a base station challenge process; and

transmit, by the convergence server, a base station challenge response to the femtocell system including a base station authentication result received from the authentication center.

**12**. The non-transitory computer-readable medium of claim **11**, further comprising instructions that, when executed by the processing system, cause the processing system to update, by the mobile station, a shared secret data key in the event the base station authentication result in the base station challenge response matches a base station authentication result produced by the mobile station.

**13**. The non-transitory computer-readable medium of claim **9**, wherein the authentication procedure request comprises a call history count update procedure, and wherein the authentication procedure request message comprises a count update message.

**14**. A system, comprising:

a core network that includes a convergence server;

a mobile core network that includes an authentication center;

an Internet Protocol-based femtocell system that provides a radio access point for a mobile station, wherein the convergence server receives an authentication procedure request from the authentication center for the mobile station, generates an authentication procedure request message that includes a registration identifier assigned to the mobile station, the registration identifier comprising a pseudo-electronic serial number derived from a mobile equipment identifier for the mobile station, and wherein the femtocell system maps the authentication procedure to the mobile station using the registration identifier;

transmit the authentication procedure request message to the femtocell system; and

receives a response to the authentication procedure request message from the femtocell system;

wherein the authentication procedure request comprises a unique challenge, the authentication procedure request message comprises an authentication request that includes a pseudo-randomly generated value, and the response includes an authentication result generated by the mobile station using the pseudo-randomly generated value and a shared secret data key.

**15**. The system of claim **14**, wherein the authentication procedure request comprises a shared secret data update procedure and the authentication procedure request message comprises a shared secret data update request message, wherein the femtocell system transmits an update order to the mobile station that includes a random number seed.

**16**. The system of claim **15**, wherein the convergence server receives a base station challenge request message from the femtocell system including a pseudo-random value selected by the mobile station, engages the authentication center in a base station challenge process, and transmits a base station challenge response to the femtocell system including a base station authentication result received from the authentication center.

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